AN AMERICAN NATIONAL STANDARD

NUCLEAR POWER PLANT AIR-CLEANING UNITS and COMPONENTS

ASME N509-1989

(REVISION OF ANSI/ASME N509-1980)

The American Society of Mechanical Engineers

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This Standard will be revised when the Society approves the issuance of a new edition. There will be no Addenda issued to ASME N509-1989.

Please Note: ASME issues written replies concerning interpretations of the technical aspects of this document. The interpretations are not part of the document. N509-1989 is being issued with an automatic subscription service to the interpretations that will be issued to it up to 1994.

FOREWORD

(This Foreword is not part of ASME N509-1989.)

This Standard covers requirements for the design, construction, and testing of components which are utilized in Nuclear Air Treatment Systems (NATS) installed in nuclear power plants. This revision was developed by the ASME Committee on Nuclear Air and Gas Treatment (CONAGT), which was assigned responsibility for maintaining ANSI/ASME N509 in 1976.

This is the third revision of this Standard. The previous revisions were issued in 1976 and 1980. The purpose of this revision is to update the Standard to incorporate technical inquiries, corrections, and state-of-the-art improvements as part of the ANSI-required five year review.

In order to gain input for this revision CONAGT held workshops in February and April of 1985. These workshops were attended by representatives from utilities, consulting engineers, testing contractors, manufacturers, and regulators. The format of the workshop provided an open forum for obtaining comments on where improvements and/or clarifications were needed. These discussions provided the basis for this revision and a revision to N509's companion standard ANSI/ASME N510.

Requests for clarifications or technical inquiries should be submitted in written form to the ASME Secretary. Technical inquiries should reference the specific paragraph in question and be phrased so that a yes/no response can be made. Unclear inquiries will be returned unanswered to the inquirer.

It is the intent of CONAGT to replace N509 and N510 with ASME AG-1, Code On Nuclear Air and Gas Treatment, in the future. AG-1 was initially issued in 1985. Those sections of AG-1 which were published when this revision of N509 was being developed have been incorporated by reference. CONAGT considers the AG-1 code requirements to be acceptable alternates to N509 requirements and therefore encourages users to utilize the latest AG-1 code requirements whenever practical. Copies of AG-1 can be obtained from ASME.

After approval by the Committee on Nuclear Air and Gas Treatment and the sponsor, and after public review, this Standard was approved and designated as an American National Standard by the American National Standards Institute, Inc. on April 7, 1989.

ASME COMMITTEE ON NUCLEAR AIR AND GAS TREATMENT

(The following is the roster of the Committee at the time of approval of this Standard.)

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NUCLEAR POWER PLANT AIR-CLEANING UNITS AND COMPONENTS

1 SCOPE

This Standard covers requirements for the design, construction, and qualification and acceptance testing of the air-cleaning units and components which make up Engineered Safety Feature (ESF) and other high efficiency air and gas treatment systems used in nuclear power plants.

1.1 Limitations

The Standard does not cover sizing of a complete nuclear air treatment system, redundancy, or single-failure requirements. It applies only to systems which employ particulate filtration, ambient-temperature adsorption, or both, as the principal functional mechanism. It does not apply to condenser off-gas systems. Also, it does not apply to other applications which employ primarily gas storage or holdup, cryogenic adsorption or fractionation, or solvent absorption as the principal method of gas treatment. Nor does the Standard cover requirements for containment isolation valves, recombiners, comfort heating, air conditioning, or ventilation to achieve ordinary cooling or industrial hygiene objectives. Field acceptance testing and surveillance testing of nuclear air treatment systems is covered in ASME N510-1989.

1.2 Purpose

The Standard identifies and establishes minimum requirements for filters, adsorbers, moisture separators, air heaters, filter housings, dampers, valves, fans, ducts, and other components of nuclear air treatment systems for a specific application in a nuclear power plant. The Standard also establishes requirements for operability, maintainability, and testability of systems necessary for the maintenance of system reliability for the design conditions. Qualification and acceptance testing provisions are specified to verify the adequacy of the air-cleaning unit and component design, to verify that components have been properly fabricated and installed, and that the system will perform in accordance with specification requirements.

2 APPLICABLE DOCUMENTS

The following documents supplement this Standard and are a part of it to the extent indicated in the text. The issue of the referenced document noted below shall be in effect. If no date is listed, then the issue of the referenced document in effect at the time of the purchase order shall apply. ANSI/ASME AG-1-1988 contains code requirements for nuclear air and gas treatment equipment. These code requirements may be substituted for the requirements listed herein.

2.1 U.S. Atomic Energy Commission (AEC), Currently the U.S. Department of Energy (DOE)

ERDA-76-21	C. A. Burchsted, A. B. Fuller, and J. E. Kahn. Nuclear Air Cleaning Handbook
MSAR-71-45	Entrained Moisture Separators for Fine Particle, Water-Air-Steam Service — Their Performance, Development, and Status
NYO-3250-6	Moisture Separator Study

2.2 American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE)

ASHRAE 52 (1976)	Method of Testing Air Cleaning Devices Used in General Ventilation for Removing Particulate Matter
ASHRAE Handbook (1982)	Applications
ASHRAE Handbook (1983)	Equipment

ASHRAE Handbook (1984)	HVAC Systems
ASHRAE Handbook (1985)	Fundamentals

2.3 Underwriters' Laboratories, Inc. (UL)

UL 900 (1986)	Test Performance of Air-Filter Units
UL 586 (1985)	High-Efficiency, Particulate, Air-Filter Units

2.4 Air Movement and Control Association, Inc. (AMCA)

AMCA 99 (1983)	Standards Handbook
AMCA 201 (1973)	Fan Application Manual — Fans and Systems
AMCA 210 (1985)	Test Code for Air Moving Devices
AMCA 211 (1985)	Certified Ratings Program Air Performance
AMCA 300 (1985)	Reverberant Room Method for Sound Testing of Fans
AMCA 301 (1975)	Method for Calculating Fan Sound Ratings from Laboratory Test Data
AMCA 500 (1983)	Test Methods for Louvers, Dampers and Shutters

2.5 American Society of Mechanical Engineers (ASME)

ASME/ANSI AG-1-1988	Code on Nuclear Air and Gas Treatment
ASME Boiler and Pressure Vessel Code, 1986 Edition — Section III, Section V, Section IX	
ANSI/ASME B31.1-1986 Edition	Power Piping Code
ASME N510-1989	Testing of Nuclear Air Treatment Systems
ANSI/ASME NQA-1-1986 Edition	Quality Assurance Program Requirements for Nuclear Facilities
ANSI/ASME NQA-2-1986 Edition	Quality Assurance Requirements for Nuclear Facilities

2.6 American Welding Society (AWS)

AWS D1.1 (1986)	Structural Welding Code
AWS D1.3 (1981)	Structural Welding Code — Sheet Steel

2.7 Air Conditioning and Refrigeration Institute (ARI)

ANSI/ARI 410 (1981)	Standard for Forced-Circulation Air-Cooling and Air-Heating Coils
ARI 680 (1986)	Standard for Residential Air Filter Equipment

2.8 Institute of Electrical and Electronics Engineers (IEEE)

IEEE 85 (1973)	Test Procedure for Airborne Sound Measurements on Rotating Electrical Machinery
IEEE 112 (1984)	Test Procedure for Polyphase Induction Motors and Generators
ANSI/IEEE 323 (1984)	Standard for Qualifying Class 1E Electrical Equipment for Nuclear Power Generating Stations
ANSI/IEEE 334 (1974)	Guide for Type Test of Continuous Duty Class I Motors Installed Inside the Containment of Nuclear Power Generating Stations
ANSI/IEEE 344 (1975)	Recommended Practices for Seismic Qualification of Class 1E Equipment in Nuclear Power Generating Stations

2.9 American National Standards Institute (ANSI)

ANSI N512 (1974)	Protective Coatings (Paints) for the Nuclear Industry
ANSI N101.2 (1972)	Protective Coatings (Paints) for Light-Water Nuclear Reactor Containment Facilities
ANSI/ANS N51.1 (1983)	Nuclear Safety Criteria for the Design of Stationary Pressurized Water Reactors

ANSI/ANS 52.1 (1983)	Nuclear Safety Criteria for the Design of Stationary Boiling Water Reactor Plants
ANSI/ASQC Z1.4 (1981)	Sampling Procedures and Tables for Inspection by Attributes

2.10 National Electrical Manufacturers' Association (NEMA)

NEMA MG-1 (1978)	Motors and Generators

2.11 American Society for Testing and Materials (ASTM)

ASTM A 36 (1984)	Structural Steel
ASTM A 123 (1978)	Zinc (Hot-Galvanized) Coatings on Products Fabricated from Rolled, Pressed, and Forged Steel Shapes, Plates, Bars, and Strips
ASTM A 240 (1984)	Heat Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels
ASTM A 283 (1984)	Low and Intermediate Tensile Strength Carbon Steel Plates, Shapes, and Bars
ASTM A 284 (1984)	Low and Intermediate Tensile Stength Carbon-Silicon Steel Plates for Machine Parts of General Construction
ASTM A 525 (1984)	General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process
ASTM A 526 (1980)	Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Commercial Quality
ASTM A 527 (1980)	Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Lock Forming Quality
ASTM A 570 (1984)	Hot-Rolled Carbon Steel Sheet and Strip, Structural Quality
ASTM A 606 (1984)	Steel Sheet and Strip, Hot-Rolled and Cold-Rolled, High-Strength, Low Alloy with Improved Atmospheric Corrosion Resistance
ASTM A 607 (1984)	Steel Sheet and Strip, Hot-Rolled and Cold-Rolled, High-Strength, Low-Alloy Columbium and/or Vanadium
ASTM A 666 (1984)	Authentic Stainless Steel, Sheet, Strip Plate and Flat Bar for Structural Applications
ASTM B 633 (1978)	Electrodeposited Coatings of Zinc on Iron and Steel
ASTM D 3843 (1980)	Standard Practice for Quality Assurance for Protective Coatings Applied to Nuclear Facilities
ASTM D 3911 (1980)	Standard Method for Evaluating Coatings Used in Light-Water Nuclear Power Plants at Simulated Loss of Coolant Accident (LOCA) Condition
ASTM D 3912 (1980)	Standard Method for Chemical Resistance of Coatings Used in Light-Water Nuclear Power Plants
ASTM E 165 (1975)	Recommended Practices for Liquid Penetrant Inspection Method
	Manual of Coating Work for Light-Water Nuclear Power Plant Primary Containment and Other Safety-Related Facilities, First Edition, 1979, Chapter [illegible]
ASTM E 300 (1973)	Recommended Practice for Sampling Industrial Chemicals

2.12 Industrial Perforators Association (IPA)

IPA (1985)	Designers, Specifiers and Buyers Handbook for Perforated Metal

2.13 Military Standards (MIL)

MIL-F-51068E (1981)	Filter, Particulate, High Efficiency, Fire-Resistant
MIL-F-51079D (1980)	Filter Medium, Fire-Resistant, High Efficiency

2.14 National Fire Protection Association (NFPA)

NFPA-803 (1983)	Standard for Fire Protection for Light-Water Nuclear Power Plant

2.15 Sheet Metal and Air-Conditioning Contractors' National Association, Inc. (SMACNA)

SMACNA (1975)	High-Pressure Duct Construction Standards

SMACNA (1985)	HVAC Duct Construction Standards — Metal and Flexible

2.16 Nuclear Regulatory Commission

NUREG 0017 - 1985	Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Pressurized Water Reactors (PWR-GALE CODE), Rev. 1

2.17 Nuclear Construction Issues Group (NCIG)

NCIG-01 (1985)	Visual Weld Acceptance Criteria for Structural Welding at Nuclear Power Plants

2.18 Code of Federal Regulations - Energy

Title 10, Part 29	Occupational Safety and Health Act
Title 10, Part 20	Standards for Protection Against Radiation
Title 10, Part 50, Appendix A	General Design Criteria for Nuclear Power Plants
Title 10, Part 50, Appendix R	Fire Protection Program for Nuclear Power Facilities Operating Prior to January 1, 1979
Title 10, Part 100	Reactor Site Criteria
Title 10, Part 50.49	Environmental Qualification of Electric Equipment Important to Safety for Nuclear Power Plants

2.19 Air Cleaning Conference

CONF-740807	"Nuclear Power Plant Control Room Ventilation System Design for Meeting General Criterion 19," Murphy, K. G. and Compe, K. M., 13th AEC Air Cleaning Conference Proceedings, 1974, p. 401
CONF-801038	"A Consistent Approach to Air-Cleaning System Duct Design," Miller, W. H., Ornberg, S. C., Rooney, K. L., 16th DOE Air Cleaning Conference Proceedings, 1980, p. 252

2.20 American Conference of Governmental Industrial Hygienists

Industrial Ventilation: A Manual of Recommended Practice — 1986

3 TERMS AND DEFINITIONS

adsorbent, batch of — the maximum quantity of material (not to exceed 10 m^3) manufactured from the same base material, processed throughout its manufacturing cycle in the same equipment and under the same manufacturing procedures, which can be homogenized at one time in one blending device and for which certified results of appropriate tests of physical and chemical properties are available. This constitutes a batch to be presented for radioactive and/or other specified tests under conditions and within tolerances specified.

adsorbent, lot of — that quantity of material consisting of one or more batches of the same type and grade, each of which meets the specified performance, physical and chemical requirements, and is shipped to the same purchaser by the same manufacturer for the same job requirement

adsorber bank or filter bank — one or more filter or adsorber cells secured in a single mounting frame, or one or more side-by-side panels containing poured or packed air treatment media, confined within the perimeter of a duct, plenum, or vault cross section; sometimes referred to as a *stage*

adsorber cell or cell — a modular container for an adsorbent, with provision for sealing to a mounting frame, which can be used singly or in multiples to build up a system of any airflow capacity

aerosol — a stable suspension of particles, solid or liquid, in air

air-cleaning unit — an assembly of components comprising a self-contained subdivision of a complete air cleaning system. It includes all the components necessary to achieve a unit air cleaning function such as removing particulate matter (filter) or iodine vapor (adsorber). A unit includes a housing plus internal air cleaning components and may include one or more auxiliary air treatment components such as prefilters, postfilters, heaters, coils, and moisture separators.

ALARA — as defined in 10 CFR 20.1(c), in addition to complying with the regulations of 10 CFR 20, the design should make every reasonable effort to maintain in-plant radiation exposures during operation and maintenance, and releases of radioactive material in effluents "as low as is reasonably achievable"

(ALARA). The term ALARA means as low as is reasonably achievable taking into account the state of technology and the economics of improvements in relation to benefits to public health and safety, and other societal and socieconomic considerations, and in relation to the utilization of atomic energy in the public interest.

bypass — a pathway through which contaminated air can escape treatment by the installed HEPA and/or adsorber banks. Examples are leaks in filters and filter mounting frames, defective or inefficient isolation dampers that result in uncontrolled flow through adjacent plenums, and unsealed penetrations for electrical conduits, pipes, floor drains, etc.

cell or adsorber cell — a modular container for an adsorbent, with provision for sealing to a mounting frame, which can be used singly or in multiples to build up a system of any airflow capacity

components, active — a component whose function is characterized by mechanical motion in response to an imposed design basis load or signal demand upon the component. Examples are motors, fans, damper operators, etc. Active safety-related components are required to perform their active function when subjected to the applicable design basis loading and environment.

components, air-cleaning — equipment that is contained in nuclear air treatment systems. Typical components may include dampers, demisters or moisture separators, heaters, prefilters, HEPA filters, charcoal adsorbers, and fans.

components, external — accessory components not normally included within an air-cleaning unit

components, internal — elements normally contained within an air-cleaning unit

contaminated space — any enclosed or outdoor space with measured or potential airborne concentrations of toxic or radioactive materials which may cause one or both of the following:

(*a*) unacceptable damage or dose to personnel or equipment occupying the space, based on 10 CFR 20, 10 CFR 50 Appendix A (General Design Criterion 19), 10 CFR 50 Appendix I limits, or plant ALARA guidelines.

(*b*) contamination of other spaces.

damper — an operable device used to control pressure or flow by varying the air path area

decontamination factor (DF) — the ratio of the concentration of a contaminant in the uncleaned (untreated) air to its concentration in the clean (treated) air

design, functional — the establishment of air cleaning efficiency, air flow rates, components to be employed, general layout spatial requirements, and operational objectives and criteria

design, mechanical — the design or selection of components, structural design of ducts and housings, sizing and layout of ducts, etc., to meet the requirements of the criteria established by the functional design. The design and layout of hardware to accommodate the criteria established in functional design.

designer or engineer — as used in this document, the individual or organization designated by the owner to be responsible for the design of air and gas treatment systems. In particular, he is responsible for the determination of the performance parameters for the system.

DOP — dioctyl phthalate (di-2-ethyl hexyl phthalate), an oily, clear, noncorrosive liquid that forms an aerosol of repeatable dimensions under given parameters of temperature, pressure flow, etc. (Note: DOP is a plasticizer and will soften many plastics on contact. Great care must be taken in the selection of organic materials used for contact with DOP.)

DOP aerosol — a polydisperse aerosol having an approximate light-scattering mean droplet size distribution as follows:

99% less than 3.0 μm
50% less than 0.7 μm
10% less than 0.4 μm

DOP aerosol generator — a device to create an aerosol from liquid DOP in the required particle size distribution

duct — an enclosed passage through which air is transferred from point to point; typically will not include air cleaning components such as HEPA filters or adsorber air-cleaning units

engineer or designer — as used in this document, the individual or organization designated by the owner to be responsible for the design of air and gas treatment systems. In particular, he is responsible for the determination of the performance parameters for the system.

engineered safety feature (ESF) — an air-cleaning unit or nuclear air treatment system that serves to control and limit the consequences of releases of energy and radioactivity in the event of occurrences as described in ANSI/ANS N51.1 and N52.1

filter bank or adsorber bank — one or more filter or adsorber cells secured in a single mounting frame, or one or more side-by-side panels containing poured or packed air treatment media, confined within the perimeter of a duct, plenum, or vault cross section; sometimes referred to as a stage

habitability system — a nuclear air treatment system whose function is to assure that plant operators are adequately protected against the effects of accidental releases of toxic and radioactive gas-borne contamination to the degree that they can safely operate the plant in case of an accident. Habitability systems must meet the requirements of 10 CFR 50, Appendix A, General Design Criteria 4, 5, and 19.

HEPA filter — a high efficiency particulate air filter having a fibrous medium with a particle removal efficiency of at least 99.97% for 0.3 μm particles of dioctyl phthalate

housing — the portion of an air-cleaning unit that encloses air cleaning components and provides connections to adjacent ductwork

interspace — any space other than the contaminated space or the protected space where the nuclear air treatment system or its parts may be located. The interspace may be considered "contaminated" if its concentration of airborne radioactivity is higher than the concentration inside that part of the nuclear air treatment system located within the interspace. The interspace may be considered "clean" if its concentration of airborne radioactivity is lower than the concentration inside the part of the nuclear air treatment system located within the interspace.

leak-tightness — the condition of a component, air-cleaning unit, or system where air leakage through or around the pressure boundary or component is less than a specified value at a specified differential pressure

manifold — a device to uniformly disperse or collect test agent mixed with air over a defined area from or into a single pipe or tube

maximum permissible concentration (MPC) — the maximum permissible concentration of radioactive materials in a given volume as specified in Appendix B in Title 10 of the Code of Federal Regulations, Part 20

mounting frame — a structure against which filters and adsorber cells may be snugly mounted and supported in a position that permits the passage of air and provides a surface to hold the sealing gasket, thereby avoiding a potential bypass or leakage path for non-filtered air

nuclear air treatment system (NATS) — a system designed to remove radioactive gaseous and particulate contaminants from a near-atmospheric pressure gas stream without significantly altering the physical properties of the inert carrier gases. Such a system contains one or both of the high-efficiency gas cleaning components referred to as HEPA filters and nuclear-grade carbon or inorganic silver containing adsorbers. These items are usually accompanied by one or more auxiliary air treatment components such as prefilters, after-filters, heaters, coils, and moisture separators. Accessories such as dampers, ducts, plenums, and fans are included when they are within or are a part of a defined pressure boundary.

owner — the organization which is awarded a construction permit from the Regulating Authority for the construction of a nuclear facility and/or the organization legally responsible for the operation, maintenance, and safety of the nuclear facility

photometer — a device to detect aerosol concentrations in air over a specified concentration range of 10,000:1

postfilter — a medium efficiency air filter having a fibrous medium with a nominal average atmospheric dust spot efficiency of not less than 95% when tested in accordance with ASHRAE Standard 52 which is used to retain carbon fines downstream of carbon adsorbers

pressure, leak test — the static pressure, acting in the direction of the operating pressure (positive or negative), used for establishing leakage rates. This pressure usually equals or exceeds the highest operating pressure of the item being tested but does not exceed structural capability pressure.

pressure, maximum design — the static pressure to which air-cleaning units and components may be subjected to and required to remain intact and which is used as the starting point for structural design. This pressure shall equal or exceed the maximum operating pressure and/or test pressure, whichever is greater. Refer to para. 4.6.5 for further information.

pressure, maximum operating — the maximum static pressure the air-cleaning units and components will be subjected to and still required to continue to perform their air-cleaning function. Static pressure resulting from off-normal operating conditions which do not render the system inoperable (e.g., closure of branch dampers or registers) shall be considered as maximum operating pressure. Refer to para. 4.6.4 for further information. The maximum operating pressure shall equal or exceed the normal operating pressure and may be equal to the maximum design pressure but may not exceed it.

pressure, normal operating — the static pressure that corresponds to the design operating mode of the air-cleaning unit, component, or system but does not include the static pressure which may be experienced in off-normal operating modes during which the system is required to continue to perform its air-cleaning function

pressure, structural capability — the static pressure to which the designer specifies the component or equipment can be safely loaded without permanent distortion. This pressure may exceed the maximum design pressure due to inclusion of a margin of safety.

pressure drop, dirty filter — the maximum operating static pressure differential (inches water gauge) of the filter elements in an nuclear air treatment system used for the design of the system

protected space — any enclosed or outdoor space where concentrations of airborne toxic or radioactive materials are limited to acceptable levels by the action of a nuclear air treatment system

residence time — the time that a contaminant or test agent theoretically remains in contact with an adsorbent, based on active volume of adsorbent and air or gas volume flow rate through the adsorber bed (e.g., volume of adsorbent in cubic feet in contact with flowing air multiplied by 60 sec/min divided by total air or gas flow rate in cubic feet per minute equals theoretical residence time in seconds)

test, acceptance — a test made upon completion of fabrication, receipt, and installation, or after modification of an installed component, air-cleaning unit, or system to verify that it meets the requirements specified

test, performance (also known as production test) — a test made on an individual production item or lot of product to verify its performance in accordance with specified requirements. Where a performance test repeats a qualification test or a previous performance test, the results of the performance test shall be within specified tolerances.

test, qualification — a test which establishes the suitability of a component (item) for a given application, generally made on either a prototype or on a typical production lot of the component

test, surveillance — an in-place leak test and visual inspection performed periodically to establish the current condition of a nuclear air treatment system and its components, with respect to bypasses and damage to filters and adsorber. Also, a laboratory test made periodically on a representative sample to determine the radioiodine removal characteristics of an adsorbent batch.

test boundary — the physical limit to the component, system, or device being subjected to a leakage test as defined in specific test procedures

test cannister — a specially designed sample holder containing sufficient adsorbent for specific laboratory tests that can be removed from an adsorber bank to provide samples for laboratory testing. A full-sized Type II adsorber cell (refer to para. 5.2 and Appendix A) may be substituted for the test cannister for the purposes of providing material for specific laboratory tests.

4 FUNCTIONAL DESIGN

4.1 General

Depending on the function of the system and the conditions under which it will operate, air-cleaning units include some or all of the following internal components.

(*a*) Prefilters are required in air-cleaning units when design inlet particulate concentrations and particle size are such that the HEPA filter may be rendered ineffective prematurely. On other air-cleaning units prefilters are recommended [illegible] when it is desired to increase HEPA filter life.

(*b*) HEPA filters are required in [illegible]r-cleaning units when filtration of inlet partic[illegible] matter requires a minimum efficiency of 99.9[illegible] particles equal to 0.3 micrometer in size.

(*c*) Adsorbers are required wh[illegible]cleaning units are designed for removal of [illegible] iodine compounds.

(*d*) Moisture separators (demiste[illegible] required when entrained water droplet concen[illegible] may be greater than 1 lb of water per 1000 [illegible] airflow.

(*e*) Heaters should be utilized for air-cleaning units with adsorbers when the relative humidity of air to the adsorber exceeds 70% based upon the [illegible] percentile meteorological conditions (where applicable). For nuclear air treatment systems which are unaffected by outside air meteorological conditions, heaters should be utilized when an accident would result in an airstream exceeding 70% relative humidity for more than 1 hr.

(*f*) *Postfilters.* When adsorbers are used in ESF air-cleaning units, provision shall be made for a postfilter to retain carbon fines. Postfilters should also be considered in non-ESF air-cleaning units discharging into occupied spaces where carbon fine carryover is not acceptable.

4.2 Design Parameters

Values of the following design parameters shall be specified when invoking this Standard and shall be used wherever referenced:

(*a*) volumetric air flow rate, acfm;

(*1*) minimum flow rate;

(*2*) maximum flow rate;

(*3*) design flow rate;

(*b*) design pressures, in. w.g.;

(*1*) maximum operating pressure;

(*2*) leak test pressure;

(*3*) maximum design pressure;

(*4*) structural capability pressure (usually determined by component designer);

(*c*) pressure-time transient (if applicable), in. w.g./sec;

(*d*) maximum and minimum gas temperature (F) and density, lb/ft^3;

(*e*) maximum inlet relative humidity (percent);

(*f*) entrained liquid water (mass flow rate), lb/min;

(*g*) concentrations of specific contaminants in airstream;

(*h*) required decontamination factors for each contaminant;

(*i*) component radiation integrated life dose and maximum dose rate (rad.);

(*j*) maximum dirty filter pressure differential, in. w.g.;

(*k*) structural loadings;

(*l*) duct and housing maximum permissible leak rate (scfm) and associated operating pressure, in. w.g.;

(*m*) environmental design conditions including temperature, pressure, and relative humidity;

(*n*) expected duration and environmental conditions of storage area;

(*o*) particle size distribution and quantity of aerosols and contaminants under normal and accident conditions (if known);

(*p*) safety classification (ESF or non-ESF);

(*q*) number of adsorber test cannisters per adsorber bank;

(*r*) heater capacity, watts, voltage, temperature differential, if applicable.

4.3 Size (Installed Capacity) of Air-Cleaning Unit

The installed capacity (cfm) of the air cleaning unit shall be no greater than the limiting installed capacity of any bank of components contained in the air cleaning unit through which the airflow must pass. The installed capacity of any bank or stage of components should not exceed the number of components in the bank times the rated capacity of the individual components. Test cannisters shall not be included in determining the installed capacity of any bank or stage of adsorbers.

4.4 Environmental Design Conditions

All parts and components of the air-cleaning unit shall be selected or designed to operate under the environmental conditions (temperature, relative humidity, pressure, radiation, etc.) specified in para. 4.2. Materials of construction and components shall be selected or treated to limit generation of combustibles and contaminants and to resist corrosion and degradation that would result in loss of function when exposed to the specified environmental conditions for the design life of the component.

Environmental qualification requirements are contained in 10 CFR 50.49 and IEEE 323.

4.5 Structural Load Requirements

ESF systems and all of their components shall be shown, either by testing or by a mathematical technique, to remain functional under the structural loading specified in para. 4.2(k) and described in para. 5.10.3.

4.6 Design Pressures

4.6.1 The nuclear air treatment system shall be designed to withstand the normal and transient pressures, to which the system may be subjected during its design life, without loss of its ability to perform its design function.

4.6.2 Four categories of design pressure are used to define the pressure the nuclear air treatment system and its components may experience. These are:

(*a*) Operating Pressure

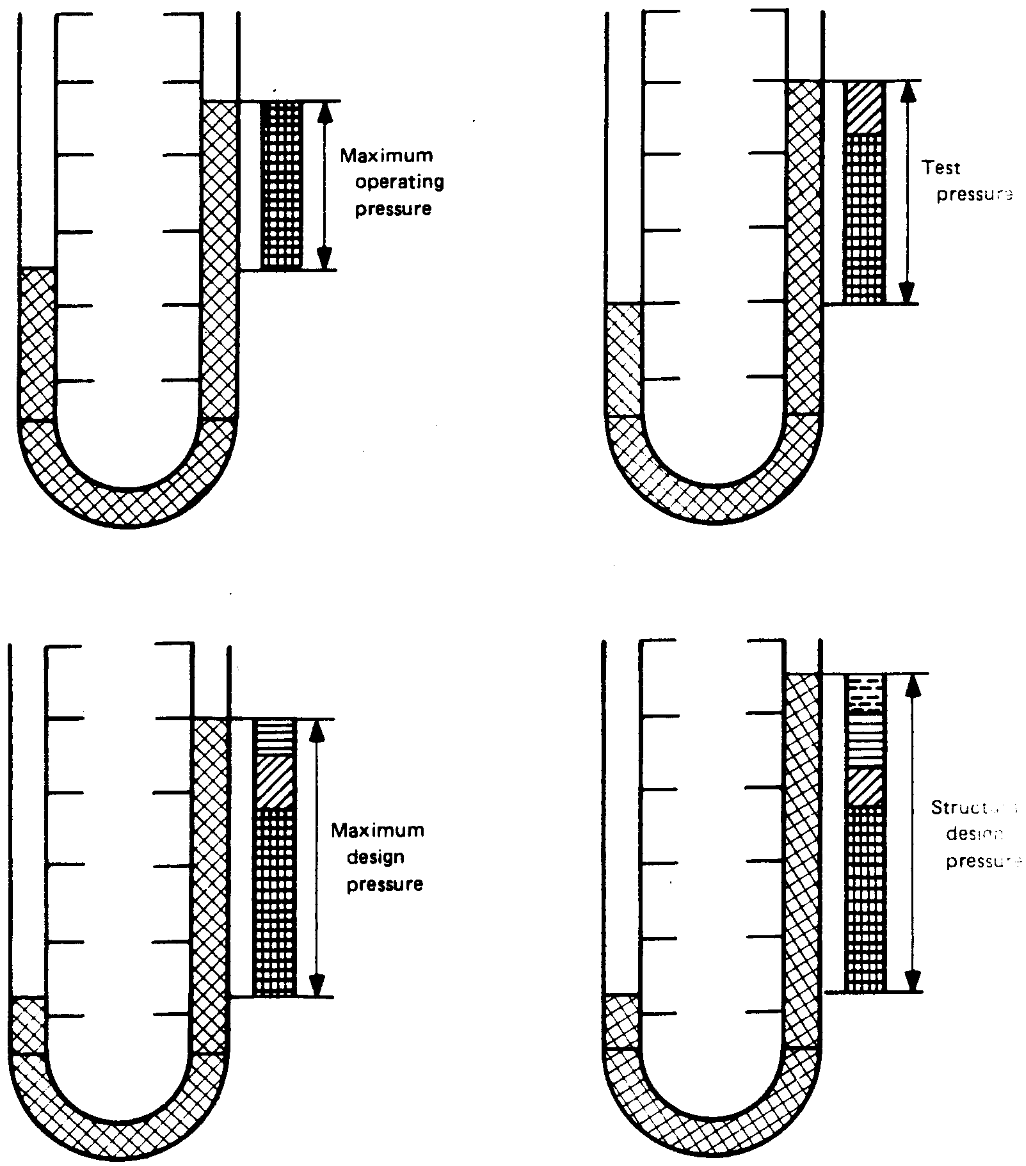
(*b*) Leak Test Pressure

(*c*) Maximum Design Pressure

(*d*) Structural Capability Pressure

Figure 4-1 depicts, in general terms, the relationship among these design pressures.

4.6.3 Operating Pressure. Operating (static) pressure shall be determined by summing the losses in total pressure of all air path components between the open atmosphere and the point in the system under consideration and deducting one velocity head from the total pressure, if positive, and adding one velocity head to the total pressure, if negative. Losses shall be based on the most severe condition of resistance to rated air



GENERAL NOTE:
See para. 3 for terms and definitions.

FIG. 4-1 PRESSURE RELATIONSHIPS

flow for the design basis operating condition and will vary throughout the nuclear air treatment system.

It is recommended that the method for determining pressure losses be derived from the ASHRAE Handbook of Fundamentals, chapter on Duct Design.

In addition to determining the normal operating pressure, the engineer shall review the system operation and determine the maximum operating pressure to which the components may be subjected to due to off-normal conditions. Examples of off-normal operating conditions where the condition will not render the system inoperable and may not be noticed, or corrected, in a short time period are closure of branch dampers or registers. The pressure associated with rapid closure of fan isolation dampers which would subsequently render the system inoperable should not be considered as a maximum operating pressure. However, this pressure should be considered in determining the maximum design pressure as discussed in para. 4.6.5.

An engineer shall include the maximum operating (static) pressure in specifications for all nuclear air treatment system components, including ducts. Fan specification requirements shall be based on either total pressure or Fan Static Pressure as defined in para. 5.7 and AMCA 201. Calculations shall document the operating pressure as the basis for determining the required test pressure (refer to para. 4.6.4) and for determination of allowable pressure boundary leakage (para. 4.14).

4.6.4 Leak Test Pressure. The pressure to be used to shop and/or field test air-cleaning units and components (such as ducts, housings, and component mounting frames) to determine air leak rates shall be specified by the engineer. The test pressure shall be the static pressure, acting in the direction of the operating pressure. This pressure usually equals or exceeds the highest operating pressure of the item being tested. The test pressure shall not be less than 4 in. w.g. for duct and housing leak tests and not less than 1 in. w.g. for mounting frame leak tests and shall not exceed the structural capability of the component (para. 4.6.6).

The test pressure for each component to be tested shall be documented by the engineer along with the operating pressure (para. 4.6.3) and included by the testing organization in the test procedures.

4.6.5 Maximum Design Pressure

4.6.5.1 Nuclear air treatment systems shall be structurally designed to withstand the maximum pressure differential which each component may experience due to normal operating pressure; test pressure; or transient pressure conditions due to rapid closure of dampers, or anticipated system upsets which would render the system inoperable. The maximum design pressure shall be equal to or greater than the maximum pressure differential after allowing for the venting effect of permanent openings and pressure relief devices in the system.

4.6.5.2 ESF nuclear air treatment systems located inside a containment structure shall be designed either to withstand the maximum differential between the primary containment structure design pressure and the normal primary containment structure operating pressure as specified in para. 4.3; or be equipped with a self-restoring pressure-relief device to limit the pressure differential from the initial post-accident transient to levels that will not cause collapse, structural damage, or loss of function.

4.6.5.3 It is not necessary to use the maximum design pressure as the basis for leak testing components if the maximum design pressure is due to transient conditions which would not be coincident with high radioactivity levels inside the pressure boundary or would not significantly alter the health physics analysis in para. 4.14.

4.6.5.4 Air-Cleaning Units and Components That Must Withstand Fan Peak Pressure

(a) Positive Pressure. Air-cleaning units and components including ducts located on the discharge side of fan(s) which can be isolated by closure of a downstream damper, or potentially plugged components shall be designed to withstand a positive internal pressure equal to or greater than the peak pressure of the fan(s). If provision is made to deenergize fan(s) on high differential pressure or low flow, the components shall be designed to withstand the trip point design pressure plus a margin to include the rate of pressure rise between reaching the pressure setpoint and the time for the instrumentation response, or 10%, whichever is greater.

(b) Negative Pressure. Air-cleaning units and components located on the inlet side of fan(s) which can be isolated by closure of an upstream damper, or potentially plugged components shall be designed to withstand a negative internal pressure equal to or more negative than the peak pressure of the fan(s). If provision is made to deenergize fan(s) on high differential pressure or low flow, the components shall be designed to withstand the trip point design pressure plus a margin to include the rate of pressure rise between reaching the pressure setpoint and the time for the instrumentation response or 10%, whichever is greater.

4.6.5.6 The maximum design pressure shall be documented by an engineer by calculation, including the basis for the condition, and included in procurement specifications for manufacturer's design.

4.6.6 Structural Design Capability Pressure

4.6.6.1 The structural design capability pressure shall equal or exceed the maximum design pressure and shall be the static pressure to which the air-cleaning unit can be safely loaded without permanent distortion. This pressure is typically a minimum of 1.25 times the maximum design pressure.

4.6.6.2 The engineer and/or component manufacturer shall document the structural design capability pressure for each component. This documentation shall be provided to the owner.

4.6.7 Example

4.6.7.1 A duct section located in a branch far from the fan is subjected to a normal operating positive pressure of 1.0 in. w.g. Under upset conditions (e.g., closure of a fire damper) the pressure could increase to 3 in. w.g. upstream of the fire damper. Furthermore, failure of the isolation damper on the fan discharge would subject a section of duct between the fan and damper to 10 in. w.g. The fan discharge duct, under normal operating conditions, experiences a static pressure of 6 in. w.g. It is expected that due to register/balancing damper closure the maximum operating pressure would be 8 in. w.g. The following design pressures would be specified:

Branch Duct

Normal Operating Pressure for Branch Duct	+1.0 in. w.g.
Maximum Operating Pressure	+3.0 in. w.g.
Test (Leak) Pressure	+4.0 in. w.g. (min.)
Maximum Design Pressure	+5.0 in. w.g.
(Selected to envelope operating and transient pressures)	
Structural Design Capability Pressure	+7.0 in. w.g. (5 × 1.25 = 6.25)

Fan Discharge Duct

Normal Operating Pressure	+6 in. w.g.
Maximum Operating Pressure	+8 in. w.g.
Duct Leak Test Pressure	+8 in. w.g.
Maximum Design Pressure (Selected to envelope Maximum Operating Pressure)	+10 in. w.g.
Structural Capability Pressure	+13 in. w.g. (10 × 1.25 = 12.5)

NOTE: All pressures noted above are static pressure.

4.6.7.2 An air-cleaning unit is located on the discharge side of an air-cleaning unit fan and is subjected to a normal operating pressure of 7 in. w.g. and maximum operating pressure of 10 in. w.g. (dirty filter conditions). It is determined that failure of discharge damper at housing outlet would subject housing to a maximum design pressure of 20 in. w.g. The following design pressures are specified:

Normal Operating Pressure	+7 in. w.g.
Maximum Operating Pressure	+10 in. w.g.
Test Pressure	10 × 1.25 = 12.5 in. w.g. use +13 in. w.g.
Maximum Design Pressure	+20 in. w.g.
Structural Design Capability Pressure	+20 × 1.25 = +25 in. w.g.

4.7 Nuclear Air Treatment System Configuration and Location

Physical location and arrangement of [illegible] components of a nuclear air treatment system [illegible] the requirements for leak tightness for the various parts of the pressure boundary. Air flow should [illegible] potentially less contaminated areas to potentially more contaminated areas. Whenever possible, [illegible]ng of contaminated air through clean spaces or [illegible]spaces should be avoided. If this can not be done, the general guidance in this section should be followed.

Nonmandatory Appendix B, Figs. B-5, B-6, and B-7, schematically depict examples of possible combinations and location of fan and air-cleaning unit to minimize impact of system contaminated outleakage on surrounding clean spaces and interspaces as well as contaminated inleakage into a cleaner system component.

General guidance for various applications is as indicated in paras. 4.7.1 through 4.7.3.

4.7.1 Effluent Nuclear Air Treatment System (Once-Through)

(*a*) Maintain ducts conveying contaminated air through clean spaces or clean interspaces at a negative pressure with respect to the surrounding areas.

(*b*) With air-cleaning unit located in a clean interspace, locate exhaust fan downstream of air-cleaning unit in order to keep air-cleaning unit under negative pressure. Any leakage through fan shaft will be from clean interspace.

(*c*) When air-cleaning units are located in contaminated spaces or interspaces, the fan shall be located upstream of the air-cleaning unit to prevent infiltration of contaminated air through fan shaft, or into the filter housing downstream of filters, thereby bypassing filters.

(*d*) The length of positive pressure discharge ducts from the air-cleaning unit routed through clean spaces or interspaces should be kept as short as practical to minimize outleakage from ductwork from impacting in-plant personnel exposure.

4.7.2 Habitability Systems

(*a*) Outside air ducts routed through clean spaces or interspaces that may convey radioactive air following a release shall be under a negative pressure relative to the spaces.

(*b*) Negative pressure recirculating air ducts that pass outside the habitable space should be avoided or additional filtration provided.

(*c*) The makeup air fan shall be located:

(*1*) upstream of air-cleaning unit if air-cleaning unit is in a contaminated space;

(*2*) downstream of air-cleaning unit if air-cleaning unit is in a clean space.

(*d*) The length of positive pressure ducts outside of the habitable boundary should be kept as short as possible to reduce effect of duct leakage on ability to pressurize habitable boundary.

(*e*) Recirculating system housings should be kept at a positive pressure if located outside habitable boundary in a contaminated space or interspace.

4.7.3 Recirculating Nuclear Air Treatment Systems

(*a*) If an air-cleaning unit is located in a clean space or interspace outside of the space served, the fan should be located downstream of the air-cleaning unit.

(*b*) Fans may be either upstream or downstream of air-cleaning units if located totally within the space served.

(*c*) The length of ductwork outside the space served should be kept to a practical minimum.

4.8 Maintainability Criteria

4.8.1 Access for Service, Testing, and Inspection. The air-cleaning unit shall be designed to keep radiation exposures during maintenance, testing and inspection as low as reasonably achievable (ALARA). Some design features which contribute to keeping these exposures ALARA are the following.

(*a*) Man-entry air-cleaning units should be located at floor level or should be equipped with a permanent service gallery at least 4 ft. wide with permanent stairs or fixed ladders.

(*b*) Smaller air-cleaning units should be located at a height above the floor or work gallery level convenient for access, based on human factors and the design of the housing.

(*c*) The area in which the air-cleaning unit is located shall be served by a clear aisle wide enough to accommodate servicing of internal components and equipment.

(*d*) Sufficiently wide clear area adjacent to the housing door or hatch shall be provided to allow servicing the air-cleaning unit; a space of at least 4 ft. wide × 7 ft. high is recommended. The clear work space may also serve as aisle space as long as it can be used while servicing the air-cleaning unit, or it may serve as the clear space for an adjacent air-cleaning unit.

(*e*) Clearance of 18 in. is recommended above the housing for installation and inspection.

(*f*) Elevated work galleries shall be designed in accordance with Occupational Safety and Health Act (OSHA) requirements.

(*g*) Ducts that will have to be cleaned out periodically shall be equipped with low leakage access hatches at strategic points.

4.8.2 Internal Space for Maintenance. For ease of maintenance, air-cleaning unit design should provide for a minimum of 3 ft from mounting frame to mounting frame between banks of components. If components are to be replaced between mounting frames, the bank-to-bank dimension should be the maximum deflated length of component plus a minimum of 3 ft. The designer should consider susceptibility of permanently installed testing manifolds to damage in determination of maintenance space. An extra 3 ft bank to bank spacing should be considered for testing manifold clearance when manifolds are permanently installed.

4.9 Monitoring of Operational Variables

4.9.1 External Effects. The designer should consider condensation, flooding, seismic requirements, temperature, humidity, radiation exposure, and vibration, as applicable, in the design of all instrument installations.

4.9.2 Instrumentation, Alarms, and Handswitches

(*a*) As a minimum, the designer shall provide the appropriate monitoring instruments, alarms and handswitches on or adjacent to each air-cleaning unit and redundant instruments, alarms, and handswitches at a remote manned control panel in accordance with Table 4-1 for ESF air-cleaning units and Table 4-2 for non-ESF air-cleaning units.

(*b*) For non-ESF air-cleaning units, a common alarm of all local alarms shall be provided on the main control room panel for each air-cleaning unit. Individual alarms may be provided on the main control room panel for each local alarm if desired in lieu of a common alarm.

(*c*) For ESF air-cleaning units, local controls shall be secured to prevent unauthorized use.

4.9.3 Qualification of Instrumentation, Alarms and Handswitches for ESF Air-Cleaning Units

(*a*) Local instrumentation and associated mountings (excluding transmitters, handswitches, limitswitches and associated mountings) shall be qualified to remain intact, but not necessarily functional under the structural loading and environment specified in para. 4.2.

(*b*) Local transmitters, handswitches, limitswitches and associated mountings shall be qualified to remain intact and completely functional under the structural loadings and environment specified in para. 4.2.

(*c*) Instrumentation, alarms and handswitches at the remote manned control panel shall be qualified to remain intact and functional for the structural loadings that may occur in the area in which the panel is located.

4.9.4 Equipment Status. Each item powered or controlled electrically (fan motor, valve or damper operator, fire protection systems, solenoid valves, etc.) shall be provided with status indication for the energized mode, located in accordance with Table 4-1 for ESF air-cleaning units and Table 4-2 for non-ESF air-cleaning units, to show the operational status of the item.

4.10 Adsorbent Cooling

Where heat of radioactive decay or heat of oxidation or both may be significant, means shall be provided to remove this heat from the adsorbent beds to limit temperatures to values below 300°F to prevent significant iodine desorption.

For this purpose, a minimum circulatory air flow shall be available for all operational modes of the air-cleaning unit and shall be based on the maximum possible radioactivity loading on the adsorbent beds. Water deluge systems are not acceptable for this purpose.

4.11 Fire Protection

4.11.1 General. Nuclear air treatment systems shall be designed, fabricated, and installed so as to minimize the use of combustibles. Filter media, sealants, gaskets, and insulation shall meet the requirements in Section 5.

4.11.2 Fire Detection. When adsorbers are provided, a fire detection system shall be installed downstream of each carbon adsorber bank to detect either abnormally elevated temperature or products of combustion. The fire detection system shall be designed to be responsive to the unique features of the installation and application (e.g., low air velocity, [illegible]ification). A two-stage alarm shall be provided. The fire detection system shall operate an alarm (first stage) upon detection of temperature above a pr[illegible]nged setpoint and automatically trip fan(s) and [illegible]late the air-cleaning unit. The second stage shall [illegible] an alarm when a fire is detected. Documentation shall be provided to the owner which shows that the [illegible] detection system is designed to be responsive to a [illegible] within the carbon adsorber bed.

4.11.3 Fire Protection Procedures. [illegible]ant fire protection procedures should include requirements that upon first-stage high-temperature alarm, the plant fire brigade is dispatched to the area to take appropriate action.

4.11.4 Fire Hazard Analysis. A fire hazard analysis shall be performed for all air-cleaning units and components in accordance with 10 CFR 50 Appendix R and NFPA 803, except that for adsorbers consideration shall be given to the type of carbon (or other media) utilized in adsorbers and the potential for fire.

4.11.5 Fire Protection Systems. Fire protection systems, when provided, may use water deluge, inert gases (e.g., Halon, CO_2) or other extinguishing agents as appropriate for the hazard and designed in accordance with all applicable NFPA standards.

4.11.6 Water Deluge Systems. Deluge nozzles should be permanently mounted within the housing and located to ensure that both the deep-seated or

TABLE 4-1 INSTRUMENTATION FOR ESF AIR-CLEANING UNITS

Sensing Location [Note (1)]	Readout/Alarm Location: Local	Readout/Alarm Location: Remote Manned Control Panel	
1. Unit Inlet (High-Velocity Portion)	F(I) alternately at location No. 16, T(I) alternately at location No. 2 or No. 4	F(AH, AL) alternately at location No. 16	
2. Space	. . .	. . .	
3. Demister	ΔP(I,AH*) [NOTE (2)]	. . .	
4. Space	. . .	. . .	
5. Electric Heating Coil	SL	. . .	
6. Space	T(I,AL,AH)	T(I,AH,AL,AT)	ΣP(AH) optional [Note (4)] (locations 6–12)
7. Prefilter	ΔP(I,AH)	. . .	
8. Space	. . .	. . .	
9. Pre-HEPA	ΔP(I,AH)	ΔP(AH)	
10. Space	. . .	. . .	
11. Adsorber	. . .	. . .	
12. Space	T(I,AH-2 STAGE) [Note (3)]	T(I,AH-2 STAGE) [Note (3)]	
13. Postfilter	ΔP(I,AH)	. . .	
14. Space	. . .	. . .	
15. Fan	HS* SL* [Note (2)]	HS,SL	
16. Unit Outlet (High Velocity Portion)	See location No. 1	See location No. 1	
17. Valve/Damper Operator	SL* [Note (2)]	SL	
18. Fire Protection System	I,AT [Note (5)]	AT [Note (5)]	

Parameters (A) [Note (6)]

F = Flow
T = Temperature
ΔP = Differential Pressure
ΣΔP = Summation Alarm (ΔP)

Instrument Function (x) [Note (6)]

I = Indication
AH = High Alarm
AL = Low Alarm
AT = Trip Alarm
SL = Status Indication
HS = Handswitch
R = Record

NOTES:

(1) The "Sensing Location" indicates the location within an air treatment unit where the specified sensors shall be located. The components are listed in the sequence they are typically used, with "Space" indicating the component between two components.

(2) All instruments are required except those marked with an (*) which are recommended.

(3) 1st Stage signals an alarm only, 2nd stage signals an alarm and permits manual actuation of fire protection system.

(4) Total air-cleaning unit ΔP alarm is optional if each component whose pressure drop is subject to change over time has individual alarm or indication in Main Control Room.

(5) Manual valves are recommended with local indication at valve. Power actuated valves, if used, shall have local handswitches, and indication; and trip alarms on local and remote manned control panels. Flow of extinguishing agent shall be alarmed on local and remote-manned control panels.

(6) A(x): Measurement of parameter A requires instrument function x.

TABLE 4-2 INSTRUMENTATION FOR NON-ESF AIR-CLEANING UNITS

Sensing Location [Note (1)]	Readout/Alarm Location: Local [Note (2)]	Readout/Alarm Location: Remote Manned Control Panel
1. Unit Inlet (High-Velocity Portion)	F(I) alternately at location No. 16, T(I) alternately at location No. 2 or 4	
2. Space	. . .	. . .
3. Demister (if applicable)	ΔP(I,AH*) [Note (3)]	. . .
4. Space	. . .	. . .
5. Electric Heating Coil	SL	. . .
6. Space	T(AH,AL,AT)	. . .
7. Prefilter	ΔP(I,AH) [Note (3)]	. . .
8. Space	. . .	. . .
9. Pre-HEPA	ΔP(I,AH*) [Note (3)]	. . .
10. Space	. . .	. . .
11. Adsorber	. . .	. . .
12. Space	T(I,AH-2 STAGE) [Note (4)]	T(I,AH-2 STAGE [illegible]
13. Postfilter	ΔP(I)	. . .
14. Space	. . .	. . .
15. Fan	HS, SL	. . .
16. Unit Outlet (High Velocity Portion)	See location No. 1	. . .
17. Valve/Damper Operator	SL* [Note (3)]	. . .
18. Fire Protection System	[Note (5)]	[Note (5)]

Parameters (A) [Note (6)]

F = Flow
T = Temperature
ΔP = Differential Pressure

Instrument Function (x) [Note (6)]

I = Indication
AH = High Alarm
AL = Low Alarm
AT = Trip Alarm
SL = Status indication
HS = Handswitch
R = Record

NOTES:
(1) The "Sensing Location" indicates the location within an air treatment unit where the specified sensors shall be located. The components are listed in the sequence they are typically used, with "Space" indicating the component between two components.
(2) For air-cleaning units located inside containment, the requirement for LOCAL controls for handswitches, flow indication, and alarms for high differential pressure, low and high flow and high temperature shall mean controls shall be located on a panel located outside containment.
(3) All instruments are required except those marked with an (*) which are recommended.
(4) 1st Stage signals an alarm only, 2nd stage signals an alarm and permits manual actuation of fire protection system.
(5) See Note (4) in Table 4-1.
(6) A (x): Measurement of parameter A requires instrument function x.

surface fires can be extinguished. Nozzles shall be piped to an accessible location outside the housing and provided with redundant leak-tight isolation (O.S.&Y.) valves and a connection suitable for manual attachment to the plant's fire protection system. Permanently connected fire protection systems are not recommended, but may be used in lieu of manual hose connections.

4.11.7 Actuation of Fire Protection Systems. If the result of the fire hazard analysis requires that a fire protection system be provided for an air-cleaning unit, the fire protection system should be manually actuated. Automatic actuating water deluge systems are *not* recommended because spurious actuation of detection/automatic protection systems will significantly degrade adsorber capability and damage the adsorber.

4.11.8 If permanently connected fire protection systems are installed, provision shall be made to activate an alarm upon initiation of flow of extinguishing agent (e.g., water, Halon, CO_2).

4.11.9 Returning Air-Cleaning Unit to Service. If carbon does become wet, the wet carbon shall be removed from the adsorber to prevent structural damage to the adsorber due to chemical interaction. Before placing the air-cleaning unit back in service, the adsorber shall be thoroughly dried, visually inspected for corrosion damage, dried carbon shall be laboratory tested per para. 5.2.3, and adsorber leak testing shall be performed per ASME N510-1989.

4.12 Insulation

Acoustic linings, thermal insulation, and similar materials shall not be applied to the inside of ducts and housings. Materials applied to the outside of ducts and housings shall not prevent access to any bolted construction joint, door, access hatch, or instrument in the housing or ducting or result in penetrations through the pressure boundary which would result in exceeding allowable leakage rates in accordance with para. 4.14.

4.13 Testability

(*a*) To ensure that the testing requirements of this Standard can be met, sufficient permanently installed halide and DOP injection and sampling ports shall be provided to permit accurate testing in accordance with ASME N510.

Where required for proper challenge agent mixing and/or sampling, multiple inlet or outlet distribution manifolds shall be provided to allow injection and sampling per ASME N510. Refer to para. 5.6.5 for detailed requirements on sampling and injection manifolds.

(*b*) Sufficient test cannisters or other means of obtaining samples (see Appendix A) of used adsorbent shall be installed in the adsorber system to provide a representative determination of the response of the adsorbent to the service environment over the predicted life of the adsorbent. Test cannisters shall be installed in a location where they will be exposed to the same airflow conditions as the adsorbent in the system, shall have the same adsorbent bed-depth as the adsorbent in the system, and shall be filled with representative adsorbent from the same batch of adsorbent as that of the system.

The quantity of test cannisters to be provided shall be based on the expected frequency of operation. For continuously operating systems, where laboratory testing of carbon is required every 720 hr of operation, a minimum of 18 test cannisters is recommended. For those systems where laboratory carbon testing is required once every 18 months, a minimum of 6 test cannisters is recommended. If the adsorber operation may vary from part time to continuous then classifying the adsorber as continuous is recommended.

The type of test cannister design (including connection to adsorber bank) shall be qualified by the manufacturer. Any change in the cannister design or mounting to bank shall require a retest. The qualification test shall measure air velocity at the test cannister. Measured velocity shall be $\pm 10\%$ of adsorber bank design velocity. Tests on each production air-cleaning unit are not required.

(*c*) Access shall be provided between banks of components in the housing to permit physical inspection of both sides of each bank; components shall not be installed back-to-back on the same or opposite sides of the same mounting frame, or on adjacent mounting frames which are so close as not to permit adequate access space between banks.

4.14 Pressure Boundary Leakage

4.14.1 Maximum Allowable Leakage. Maximum allowable leakage across the pressure boundary of any portion of an nuclear air treatment system shall be based on health physics requirements. Leakage into or out of nuclear air treatment systems may affect:

(*a*) control room habitability;

(*b*) plant personnel exposure during normal plant operation due to contaminated outleakage in clean spaces or clean interspaces;

(*c*) plant personnel exposure due to excessive system inleakage which prevents the nuclear air treatment system from performing its design function in contaminated spaces or contaminated interspaces during plant normal, upset, or accident conditions;

(*d*) offsite exposure during plant normal, upset, or accident conditions.

4.14.2 Calculation of Allowable Leakage. The system designer (engineer) shall determine leakage criteria and allowable leakage to meet governing codes, standards, regulations, and plant-specific requirements for required portions of the nuclear air treatment system pressure boundary (ducts, housing, dampers, fans, etc.) The basis for determining the leak rate, the leak rate value(s), and coincident operating (static) pressure shall be documented and provided to the owner.

Additional leakage criteria may be applied to the pressure boundary as determined by the owner to meet plant-specific ALARA programs and/or regulatory requirements.

Additional leakage criteria can be found in nonmandatory Appendix B, including examples of determining allowable leakage for typical installations.

4.14.3 Leak Test Parameters. Components shall be designed, fabricated, and installed so as not to exceed allowable leakage at specified operating pressure.

Where shop and/or field tests are required by Table 9-1 and ASME N510, the system designer shall specify the test pressure and corresponding maximum allowable leak rate (scfm). Test pressure shall be selected based on the test procedures in ASME N510 and the maximum operating (static) pressure.

If the leak rates are measured at a test pressure not equal to the operating static pressure, the measured leak rates shall be converted as follows to allow comparison to allowable unit leak rates at operating pressure:

$$L_t = L_{op} \left(\frac{P_t}{P_{op}} \right)^{1/2} \qquad (1)$$

where

L_t = allowable unit leak rate at test pressure, cfm/ft^2

L_{op} = allowable unit leak rate at operating (static pressure, cfm/ft^2

P_t = selected test pressure, in. w.g.

P_{op} = operating (static) pressure, in. w.g.

NOTE: This assumes fully turbulent flow at both test pressure and operating pressure. If flow is not fully turbulent, then the appropriate relationship between airflow rate and pressure shall be used.

5 COMPONENTS

5.1 HEPA Filters

HEPA filters shall meet the construction, material, test, and qualification requirements of military specification MIL-F-51068, except that listing of manufacturer's HEPA filter products on the U.S. Army's Qualified Products List is not required. Glass fiber media shall conform to the requirements of military specification MIL-F-51079. To be acceptable, filters shall have documentation showing that they have passed the tests designated by MIL-F-51068 for:

(*a*) newly designed HEPA filters,

(*b*) HEPA filters from a new manufacturer or a new manufacturing facility,

(*c*) HEPA filters being rerated for a higher airflow than originally qualified for.

Requalification is required to be performed by the manufacturer every 5 years.

5.1.1 Construction. Filters for use in containment or in ESF systems shall be metal case type (Type II frames as defined by MIL-F-51068) and shall be compatible with the chemical composition of the air stream. Filter systems exposed to temperatures greater than 200°F shall have steel cell sides.

5.1.2 Radiation Resistance. Radiation resistance of filter media shall meet the requirements of MIL-F-51079 and conditions listed in para. [illegible]

5.1.3 Documentation

5.1.3.1 A Certificate of Conformance shall be provided to the owner certifying that:

(*a*) the filter assembly has been designed in accordance with para. 5.1;

(*b*) the materials of construction comply with paras. 5.1, 5.1.1, and 5.1.2;

(*c*) the filters and filter media have been qualified in accordance with para. 5.1;

(*d*) the filters and filter media have been tested in accordance with para. 5.1;

(*e*) the filters have been packaged in accordance with para. 6.

5.1.3.2 In addition, the following documentation shall be provided:

(*a*) copies of the production test results required by Military Standards;

(*b*) copies of all filter case material certifications, if required by the owner's purchasing documents.

5.1.3.3 Listing of Manufacturer's HEPA filter products on the U.S. Army's Qualified Products list is not required.

5.2 Adsorbers

5.2.1 Flat Bed and Pleated Bed Adsorber Cells. Tray-type and deep bed adsorber cells shall meet the requirements for Type II or Type III cells, respectively, of ASME/ANSI AG-1-1988, Sections FD, Type II Adsorbers, and FE, Type III Adsorbers; and shall be filled with an adsorbent, each batch of which meets the requirements of para. 5.2.3.

5.2.2 Adsorber Design

5.2.2.1 Joints which are gasketed, caulked, or sealed with elastomeric materials shall not be employed between the upstream and downstream sides of the adsorbent bed, frames, or any part of the installation. Test cannisters for Type II Adsorbers, or reservoir covers for Type III Adsorbers shall be gasketed to the mounting surface. Perforated metal shall be installed with the smooth side in contact with carbon.

5.2.2.2 The adsorbent bed shall be so arranged that no air can bypass the adsorbent and the minimum residence time of air in the adsorbent is 0.25 sec per 2 in. bed depth. If there is significant potential for adsorber degradation due to "poisoning" from contaminants in the airstream, a bank of unimpregnated carbon may be installed upstream of the impregnated adsorbent. There shall be no internal structures within the adsorbent bed, such as through-bolts, where air bypass can occur.

5.2.2.3 Screens shall be supported by stiffeners which are external to the adsorbent bed to assure uniformity and integrity of the bed.

5.2.2.4 Means shall be provided for filling the air-cleaning unit with absorbent and compacting it to uniform packing density throughout all cross sections of the bed. In a vertical direction, this density shall vary only to the extent that the lower portion of the bed supports the weight of the adsorbent placed above it. Adsorbers shall be filled in accordance with Appendix D of ASME/ANSI AG-1-1988, Section FE. For designs in which a fill hopper is included in the design, a 5% by weight reserve capacity beginning one bed depth above the perforated screen shall be included.

5.2.2.5 All materials in contact with the adsorbent shall be Type 300 Series stainless steel.

5.2.2.6 Means shall be provided for emptying adsorbent, including wet or caked adsorbent. Direct access to the top and bottom portion of the air-cleaning unit should be provided for emptying adsorbent. The manufacturer of the air-cleaning unit shall provide instructions for removing the adsorbent under a variety of conditions, including while wet and caked. ALARA considerations should be incorporated into manufacturer's design.

5.2.3 Adsorbent Requirements

5.2.3.1 Adsorbent media used in ESF adsorbers shall meet the requirements of ASME/ANSI AG-1-1988, Section FF, Adsorbent Media.

5.2.3.2 Adsorbent media used in non-ESF adsorbers shall meet the requirements of ASME/ANSI AG-1-1988, Section FF, Adsorbent Media.

5.2.3.3 For ESF and non-ESF adsorbent, tests shall be conducted on unused adsorbent for the conditions specified in the plant's Technical Specifications. These tests shall be referred to as benchmark surveillance tests. Acceptance criteria shall be in accordance with Technical Specifications. These results may be used as a benchmark for comparing adsorbent test performance after acceptance testing and following each periodic surveillance test.

5.2.4 Drawings. Outline drawings showing major dimensions, dimensional tolerances, methods of sealing and baffling, and method of installation shall be furnished. The drawings for all adsorbers shall show the materials of construction and screen details (hole diameter and spacing, open area) in accordance with the IPA Designers, Specifiers and Buyers Handbook for Perforated Metal.

5.2.5 Documentation

5.2.5.1 Standard Adsorber Cells. A report giving the information specified in Sections FD, FE, and FF of ASME/ANSI AG-1-1988 shall be furnished to the owner.

5.2.5.2 Other Adsorber Designs. A report giving the information specified in para. 5.2.5.1 shall be furnished to the owner. A detailed written procedure for filling and emptying the adsorber shall also be furnished.

5.3 Prefilters and Postfilters

Prefilters and postfilters shall be replaceable, extended media, dry type, meeting the requirements for Group III filters of ARI 680, and shall be listed as Class I filters in the current UL Building Materials Directory. Media should be moisture resistant.

5.3.1 Rating. Filters shall have published ratings, in accordance with ARI 680, as follows:

(*a*) average atmospheric dust-spot efficiency in accordance with ASHRAE Standard 52, for postfilters of 95%, and 45% for prefilters;

(*b*) airflow capacity: same as or greater than HEPA filters for the same filter frame face area.

5.3.2 Size. It is recommended that the filter frame face dimensions of prefilters be approximately the same (i.e., within ± 1 in.) as the filter frame face dimensions of the HEPA filters with which they will be used.

5.3.3 Documentation. A report giving the outline dimensions, description of construction, materials of construction, certification of conformance with UL-900, and certification of efficiency in accordance with ASHRAE Standard 52 shall be furnished to the owner.

5.4 Moisture Separators

Moisture separators shall be of a design that has been qualified by testing in accordance with the procedures described in MSAR-71-45, NYO-3250-6, or an equivalent program. Moisture separators shall be found by test to be capable of:

(*a*) removing at least 99% by weight of the entrained moisture in an airstream containing approximately 1.5 to 2 lb of entrained water per 1,000 cu ft, and

(*b*) at least 99% by count of 5 to 10 μm-diameter droplets, without visible carryover, when operating at rated airflow capacity.

The pressure drop at rated flow, when dry and when wet, shall be established by qualification testing. Materials of construction (media, gaskets, etc.) shall be such that the moisture separator can perform its design function under the radiation dose specified in para. 4.2. Liquid removed by the moisture separators shall be sent to a liquid radwaste system or a building equipment drain sump. The selection of the system to which this liquid is sent should be based upon its capability to handle the quantity and radioactivity level of the liquid associated with the anticipated moisture separator drainage. Drainage should not be open and ALARA considerations should be accounted for in drainage design. The drainage system shall be designed so that it does not result in a bypass around air cleaning components. Drains shall meet the requirements of para. 5.6.2.

5.4.1 Drawings. Drawings showing the details of construction, methods of sealing, baffling, and draining, dimensions, dimensional tolerances, resistance characteristics, and method of installation shall be furnished to the owner. The locations and sizes of drains to remove collected water, materials of construction, and other information required to properly install, use, and maintain the moisture separators shall be included on the drawings.

5.4.2 Documentation. A report showing the results of satisfactory qualification testing of the type of moisture separator proposed shall be furnished to the owner if the equipment supplied has not been previously satisfactorily tested and reported in available published literature as in MSAR-71-45, NYO-3250-6, or other documents of comparable detail.

5.5 Air Heaters

Heaters shall be electric and capable of meeting the requirements of para. 4.5 of this Standard. Qualification tests may be made on small scale models of the complete heating assembly. Heaters shall be designed for replacement without metal cutting or welding. Heaters shall not be attached directly to grounded to the adsorber mounting frame. Heaters shall be physically sized such that face velocity exceeds manufacturer's minimum requirement. This will usually result in a heater with a smaller cross-section than prefilter or HEPA filter banks. Heaters should therefore be located relative to HEPA filters such that a uniform airflow distribution at the HEPA filter can be obtained. The design of the air-cleaning unit should incorporate diffuser plates or other means to achieve uniform airflow distribution at the HEPA filters in accordance with ASME N510, if necessary.

5.5.1 Heater Stage. The heater stage shall be sized on the basis of heat transfer calculations showing a capability of reducing the maximum expected relative humidity of the entering airstream mixture to approximately 70% in the housing space between the moisture separator or housing inlet (whichever is applicable) and the prefilter stage, at the system design flow rate. The sensible heat produced by the heater stage shall not result in increasing air temperatures to more than 225°F. An overtemperature cutoff switch set at this value shall be provided. Manually reset overtemperature cutoff switches are not recommended for ESF air-cleaning units located in areas not accessible following a DBA.

5.5.2 Drawings. Drawings showing the details of construction, dimensions, dimensional tolerances, size and location of services (i.e., electrical connections), and method of installation shall be furnished to the owner.

5.5.3 Heaters for ESF Systems. Heaters in ESF air-cleaning units shall be qualified to meet the requirements of IEEE 323 and IEEE 344.

5.5.4 Documentation. A report containing description and results of qualification testing, and the resistance, certification and serial number(s) of the heaters purchased shall be furnished to the owner. If small scale model tests are the bases of design, scaled-up calculations must be provided. Heat transfer calculations shall be submitted to the owner if requested.

5.6 Filter Housing

5.6.1 General Requirements. Housings shall be designed and constructed to meet the structural and pressure loadings of Section 4. Welding shall conform with para. 7.3. Layout of the housing and banks of components within the housing shall provide for access to both sides of each bank of components for maintenance and testing; and for uniform airflow (within ± 20% of average) through each bank of components; the completed housing shall meet the requirements of the air-flow uniformity test of ASME N510. It is recommended that no filter or adsorber bank be higher than three 24 in. × 24 in. HEPA filters or nine Type II adsorber cells unless permanently installed service galleries are provided at approximately 7 ft. intervals with permanently installed ladders to provide for access to upper tiers of components for service and testing.

HEPA filter and adsorber mounting frames shall meet the requirements of para. 5.6.3, and shall be sealed into the housing by welding; no mastics, sealants, or caulking compounds shall be used to seal the mounting frame. Duct and fan connections shall be located with respect to the air distribution uniformity requirement specified above. Housings shall be tested by the manufacturer in accordance with para. 5.6.5.

5.6.2 Mechanical Design of Housings

(*a*) *Housing Doors*

(*1*) *Design.* Doors and door frames shall be of marine bulkhead type or equivalent airtight construction capable of meeting the pressure-leak requirement of para. 5.6.1.

Doors shall be of sufficient strength to withstand the worst-case combination of possible loads without deformation that would impair function or unacceptably impact pressure boundary integrity. This shall include both long term loads (i.e., door clamps, door weight, pressure differential) and short term loads (such as pressure surges, closing/opening door, etc.).

Housing doors should avoid the use of sharp edges which could catch or tear protective clothing.

(*2*) *Size.* Doors shall be of sufficient size that passage is possible by a person wearing anticontamination clothing and a respirator, and carrying the largest routinely replaceable component used in that compartment. Where the housing size is less than the door required, alternate methods of clamping, replacement, inspection, and testing must be provided. Man-entry doors shall have a minimum clear opening of 20 in. wide × 50 in. high.

(*3*) *Seals.* Sealing surfaces between door and door frame shall be designed for compression sealing. Door design shall incorporate means for adjusting compression forces and gasket compression. Gaskets shall be installed on door and a "knife edge" sealing surface for the gasket shall be provided. Gasket shall be neoprene or silicone rubber with a recommended 30-40 Shore-A durometer.

The gasket shall be installed in as few pieces as possible to minimize number of joints. Gasket joints shall be dovetailed-type to prevent leakage due to misfitting butt joints.

The gasket shall be protected from possible damage when the door is opened by installing gasket within a channel or with a metal bar between door edge and gasket to protect it in an equivalent manner.

(*4*) *Hinges and Latching Lugs.* Door hinges shall be of sufficient strength to hold the door in correct position for gasket sealing. They shall allow free, low-torque movement of the door. Hinges shall be articulated so the door will seal against the gasket in the same manner as if only a single axis was provided.

Latching lugs shall be of sufficient number, design, location, and strength for long-term life and use. Spacing shall enable a compression of at least 50% of nominal gasket thickness and provide a gasket compression uniformity of ±20%.

(*a*) Lugs shall be located on all four sides of each door.

(*b*) There shall be a minimum of six or eight lugs, depending on door size (one top, one bottom, two or three on each side). Doors with a width greater than 30 in. shall be provided with a minimum of two lugs on top and bottom.

(*c*) Lugs shall seal in less than 270 deg. motion.

(*d*) Lugs shall not have more than one handle per location; that is, there shall not be a handle to position the inside clamp and a separate handle to tighten the clamp down.

(*e*) Lugs shall be configured so that when open, gravity will hold them in the open position.

(*f*) Lugs shall indicate (or have permanent indication on the door) which direction to turn to open or close. This shall be for each lug, or if all work the same, then indicated once on each door.

(*g*) Lugs should open and seal with only the torque that can reasonably be applied by an average person while suited up. If additional torque is required, a specific tool to provide the torque shall be supplied for each door, and so attached as to reasonably assure that it will be available during the life of the plant.

(*h*) Latching lug assemblies shall have a minimum number of components and be designed so no loose components can fall off.

(*i*) Latching lugs shall be designed to operate with no lubricant required within the pressure boundary.

Doors shall have provisions for locking and be fitted with inspection windows. Windows should be wire glass or high-strength plastic selected for the operating environmental conditions. Doors shall be operable from both sides. Sufficient clearance shall be provided to enable doors to be opened so that they do not block access to service aisles and can be opened sufficiently to enable access for testing, filter replacement, repair, or inspection.

Drawings for each type and size door shall be submitted to the owner for review prior to fabrication. Door drawings shall show location and details of hinges, latching lugs, and viewports. Details on latching lug design (including shims and washers) and gasket installation shall be included.

(*b*) *Lighting.* Housings shall be fitted with vaportight lights between each bank of components. Lighting fixtures shall be flush-mounted and serviceable from outside the housing. Lighting levels shall be determined based on personnel safety and inspection and testing needs. Supplemental lighting for periodic inspection may also be used. The light switch for each light shall be located on the outside immediately adjacent to the door to the space served by the light. Conduits shall be located on the outside of the housing.

(*c*) *Drains.* Each housing compartment shall have floor drains which meet all allowable air leakage criteria.

When piped to a common drain system, individual drainlines shall be valved, sealed, trapped, or otherwise protected to prevent bypassing of contaminated air around filters or adsorbers through the drain systems, inducing air from contaminated interspaces into the air-cleaning unit, or blowing contaminated air from the air-cleaning unit to a clean interspace.

Special consideration shall be given to additional drains depending on required services or components within each compartment. For example, additional drains may be required for:

(*1*) moisture separators

(*2*) condensing cooling units

(*3*) adsorber water deluge fire protection sprays

The size selected for each drain furnished in a housing shall be verified by calculation or test, and documented.

The number of normally open drains should be kept to a minimum (i.e., drains should be manually valved off when not needed during operation to reduce the possibilities of degrading the pressure boundary or bypassing the air-cleaning unit or filter banks.

Traps or loop seals when used should be designed for the maximum operating (static) pressure the air-cleaning unit may experience during system startup, normal operation, system transients, [illegible] system shutdown. Provision should be made for [illegible] or automatic fill systems to ensure water [illegible] do not evaporate. If manual filling is utilized [illegible] periodic inspection or filling procedure shall be [illegible]ented. A sight glass should be considered to [illegible] inspection. The same applies if a local sump [illegible] in the design.

The drain system shall be designed [illegible] unacceptable backup of liquids into the housing [illegible] not occur. Hydraulic calculations shall be prep[illegible] document this feature of drain system design. P[illegible] shall be made in plant radwaste system to [illegible] maximum coincident flow rate.

Initial testing of the drain system shall be performed by the owner on site, after installation, to demonstrate operability.

When shutoff valves or check valves are utilized, they shall be initially tested on site, after installation, and periodically thereafter for operability and leakage.

Valve leakage shall be considered as part of the allowable housing leakage criteria derived in para. 4.14. For check valves, surveillance inspections for operability and leakage shall be performed periodically in accordance with air-cleaning unit Technical Specification requirements.

(*d*) *Housing Penetrations.* All penetrations shall be sealed by welding or having adjustable compression gland-type seals.

All penetrations by electrical conduit piping and sample and test manifolds shall be arranged and individually sealed or valved so that bypassing of HEPA filters or adsorbers cannot take place. Electrical conduit open to the inside of the housing shall be internally sealed to meet the allowable leakage specified in para. 4.14.

(e) *Housing Connections*

(1) Duct-housing interconnections shall be designed with consideration for air distribution uniformity requirement of ASME N510-1989. Provision shall also be made to bolt on access covers on the housing inlet and outlet connections to facilitate in-place leakage testing.

(2) Connection flange requirements shall be in accordance with para. 5.10.

(3) To allow for periodic housing pressure surveillance testing, a 6 in. diameter, 1 ft long, flanged connection with a welded longitudinal seam shall be provided at the housing inlet or the housing outlet for connection to leak test blower assembly. A flanged, gasketed cover plate shall be bolted to the connection.

(f) *Flexible Connections*

(1) Flexible connections shall be designed to meet the requirements of paras. 4.2, 4.6, and 4.14.

(2) Flexible connections shall be rated by pressure and qualified life. The qualified life shall be determined by testing and/or calculation and based on the environmental conditions provided by the Design Specification. Minimum physical properties (i.e., tensile strength) that are required to satisfy design function and which are subject to degradation due to the environment shall be the basis of qualified life.

(3) Flexible connection pressure rating shall be determined by an ultimate strength test. The pressure rating of the connection shall be no greater than 50% of burst pressure. Calculation of burst pressure can be done in lieu of a test. Burst pressure shall exceed structural capability pressure.

(4) For qualification, flexible connections shall be stressed over a minimum of 10 cycles and then leak tested to demonstrate leak-tight integrity. Allowable leakage and test pressure (fabric leakage and joint leakage) shall be determined in accordance with para. 4.14.

(5) If adhesive is used in fabrication or installation of flexible connections, it shall be environmentally qualified for use in expected environmental conditions.

(g) *Housing Drawings.* Housing drawings showing location and size of each door, drain, and housing duct or pipe connection shall be submitted to the owner prior to fabrication. Drawings should also show location of lights, switches, and other appurtenances. Location of heaters, coils, filter banks, and service space between banks shall be dimensioned. Drawings shall include sufficient detail to allow calculation of internal volume for housing and frame leak testing.

Detailed drawings and operating instructions in accordance with para. 5.6.2 shall be submitted prior to fabrication.

Details of flexible connection construction, installation, and qualification shall be submitted prior to fabrication.

Details of drain systems showing location, pipe size, type of seals (valves, loops) shall be submitted to owner prior to fabrication. Detailed valve drawings shall be submitted, if used. Hydraulic calculations and leakage test results shall be submitted prior to shipping.

5.6.3 Component Mounting Frames. Mounting frames for all components (moisture separators, prefilters, heaters, HEPA filters, adsorbers, and postfilters) shall be all-welded construction and seal-welded into the housing to prevent trapping of contamination between frame and housing.

HEPA filter frames shall be of a face-sealed design meeting the structural requirements of para. 4.3 of ERDA 76-21 or be otherwise designed to prevent relative flexure between the frame and the components mounted on the frame. Clamping of HEPA filters and adsorbers which employ gaskets for sealing to the frame shall be by a method which will produce a gasket compression-deflection of at least 50% without exceeding a stress in the clamping device of 67% of its yield strength, and which will produce a uniformity of gasket compression within ±20% of the average compressed thickness. Threaded latching devices shall be stainless steel with non-galling mating parts. Adsorber frames shall be of a type which will adequately support the type of adsorber used; faces of the frame shall meet the tolerances of HEPA filter frames given in Table 4-2 of ERDA 76-21, and clamping devices shall meet the requirements specified above for HEPA filter frames. Frames should be vertical (horizontal airflow); horizontal mounting frames are not recommended. There shall be no penetrations of any component mounting frame, except for test cannisters. HEPA filters and Type II adsorber cells shall be individually clamped to their mounting frames. Recommendations for mounting frames and component installation are given in paras. 4.3 (for bank installations) and 6.2.1 (for single filter installations) of ERDA 76-21. Drawings of clamping devices for HEPA filters and Type II adsorber cells shall be submitted to the owner prior to fabrication.

5.6.4 Materials and Protective Coatings

5.6.4.1 Materials of Construction. Carbon, stainless, and galvanized steel, aluminum, copper, bronze, or glass used for the fabrication of parts, components, air-cleaning units, and systems covered by this Standard shall meet the requirements of, and be furnished in accordance with, ASTM standards applicable to the type of material or item. The ASTM number(s) for all such material and copies of supporting documentation (i.e., test reports and/or materials-manufacturer's certification) shall be filed by the fabricator and made available to the owner on request. Where a specific ASTM standard is required for an item covered by this Standard, the designer shall specify and the fabricator shall use such material. Where post accident spray chemistry may cause H_2 generation, the use of any material incompatible with the spray chemistry shall be avoided.

5.6.4.2 Internal and external surfaces of both ESF and non-ESF housings located inside containment shall be stainless steel or be treated with a paint or protective coating that meets the requirements of ANSI N101.2[1] (for light-water reactors) or the requirements for "severe exposure" of ANSI N512[2] (for nuclear facilities other than light-water reactors): the selection, application, and inspection of paints and coatings shall conform to and be documented in accordance with the requirements of ASTM D 3843.[3] Bronze, copper, aluminum and glass need not be coated. Where conditions do not restrict its use (e.g., when no chemical additives are used in containment spray systems), galvanized steel and aluminum are acceptable for external and internal housing surfaces.

5.6.4.3 Internal surfaces of ESF systems located outside of containment shall be stainless steel, galvanized or electrolytic-zinc-coated steel, or treated with a paint or protective coating meeting the requirements for Service Level I, of ANSI N512 and Table 5-1; the selection, application, and inspection of paints and protective coatings (including zinc to the extent applicable) shall conform to and be documented in accordance with the requirements of ASTM D 3843. Bronze, copper, aluminum, and glass need not be coated. Internal surfaces of normally operating systems shall be treated to meet the requirements of Service Level II of ANSI N512 if environmental conditions do no significantly change between normal and postaccident operation. For Service Level II coatings, the requirements of Table 5-1 apply; however, the requirements of ASTM D 3843 do not.

Nongalvanized carbon steel external surfaces shall be coated or painted for corrosion resistance. Where conditions exist outside of containment (e.g., in systems containing sprays with chemical additives) which restric the use of aluminum, galvanized or electrolytic-zinc-coated steel, external and internal surfaces of ESF housings shall be in accordance with para. 5.6.4.2.

5.6.4.4 Internal and external carbon steel surfaces of non-ESF systems located outside of containment may be galvanized steel, electrolytic-zinc-coated steel, or painted.

5.6.4.5 Galvanized surfaces shall meet the requirements of ASTM A 123; electrolytic-[illegible]coated surfaces shall meet the requirements of [illegible] of ASTM A 164. Edges of steel sheared af[illegible]ing, welds, and areas in which the galvanized [illegible] has been removed for any reason shall be trea[illegible] inorganic zinc rich paint (qualified to ANSI [illegible]) to restore the corrosion resistance of those [illegible]

Galvanized surfaces that have been dam[illegible] shall be repaired with an appropriate qualified [illegible] per ANSI N101.2. The damaged areas shall be [illegible]d to provide an equivalent to the original coat[illegible]

5.6.5 Testing

5.6.5.1 Sampling and injection manifolds installed within the filter housing should be designed for permanent installation within the housing. If permanently installed manifolds cannot be provided, then manifolds shall be designed to be removable with each manifold piece numbered, tagged with permanent metal tags, and marked for reinstallation prior to each test. It should be noted that permanent manifold installations are highly recommended in order to obtain better repeatability of test results and to eliminate the need to enter housings which will decrease personnel radiation exposure. As a minimum, injection and sampling manifolds are required between each pair of HEPA filter banks and between each pair of carbon adsorber banks. For systems with no inlet ducts or no outlet ducts, injection manifolds and sampling manifolds shall be located within the housing. Manifolds

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[1] ASTM D 3911 shall be substituted in the applicable paragraphs of ANSI N101.2 regarding DBA requirements.

[2] ASTM D 3912 shall be substituted for chemical resistance tests in ANSI N512. ASTM D 4256 shall be substituted in applicable paragraphs for decontaminability tests of N512. ASTM D 4082 shall be substituted in applicable paragraphs for radiation tolerance tests of N512.

[3] ASTM D 3843 shall be substituted for ANSI N101.4 in applicable paragraphs of ANSI N101.2 and N512.

TABLE 5-1 COATING PERFORMANCE REQUIREMENTS[1]

System Type	Surface	General Exposure Condition [Note (2)]	Radiation Exposure, rads	Decontamination Factor [Note (3)]	Chemical Resistance [Note (4)]	Physical Properties [Note (5)]
Air treatment	Internal	Light	$<5 \times 10^8$	10, min.	Chem. exposure	All
Air treatment	External	Light	$<5 \times 10^8$	5, min.	Chem. exposure	All, except abrasion

NOTES:
(1) Coating performance requirements in accordance with ANSI N512.
(2) General Exposure Conditions per Section 2 of ANSI N512.
(3) Decontaminability per Section 4 of ANSI N512. Minimum value specified.
(4) Chemical resistance test (lining test or chemical exposure test) per Section 5 of ANSI N512.
(5) Physical tests (abrasion, adhesion, direct-impact resistance, weathering) per Section 6 of ANSI N512.

should conform with the general guidance given in Appendix C.

Manifolds shall be:

(*a*) located to provide uniform mixing and sampling of the test agent,

(*b*) located to allow for maintenance of the filter elements, and

(*c*) designed such that they do not impair the function of the adjacent filter banks or the structural integrity of the filter frames or housing when subjected to the structural loadings listed in para. 4.2.

Each injection and sampling manifold shall be shown on a drawing which indicates location within the housing, distance from components, support detail, tube diameters, hole locations and diameters, location of valves and plugs, manifold identification number, and manifold internal volume.

Drawings shall be submitted to the owner for review prior to fabrication and final as-built drawings submitted to the owner after shop testing.

Manifold design and location shall be qualified by shop tests per paras. 5.6.5.5 and 5.6.5.6.

5.6.5.2 Housings shall be visually inspected in the shop prior to shipping. Visual inspection shall be performed in accordance with applicable sections of ASME N510-1989, Section 5. Observed deficiencies shall be documented on a visual inspection checklist, required corrective action noted, and results of reinspection documented. Visual inspection documentation shall be transmitted to the owner for his records.

5.6.5.3 All HEPA filter frame and adsorber bed welds which could result in leakage bypassing HEPA filters or adsorber beds shall be shop tested with magnetic particle or liquid penetrant in accordance with the requirement in para. 7.3. In addition, each HEPA and adsorber frame shall be pressure leak tested in the shop in accordance with ASME N510, Section 7. Leakage shall not be greater than 0.1% of rated flow.

5.6.5.4 Housings or housing sections shall be leak tested in the shop prior to shipment, in accordance with ASME N510, Section 6. Leakage shall be no greater than acceptance criteria provided by the owner. Results of housing leak tests shall be transmitted to the owner for his records.

5.6.5.5 Airflow distribution testing shall be performed in the shop prior to shipment in accordance with ASME N510, Section 8 to provide assurance that manufacturer's design provides uniform air distribution. Shop tests shall simulate actual field entrance and exit duct connections as closely as possible. Field testing shall also be conducted in accordance with ASME N510.

Air-cleaning units which are duplicates in design layout, and fabrication to other air-cleaning units which have been successfully tested and documented, need not be shop tested for airflow distribution. Acceptance criteria shall be as given in ASME N510. Results of airflow distribution tests shall be documented and transmitted to the owner for his records.

5.6.5.6 Air-aerosol mixing uniformity tests shall be performed in the shop for each manifold which is provided by the manufacturer to be mounted within the filter housing. Air-cleaning units and test manifolds which are duplicates in design, layout, and fabrication to other air-cleaning units which have been successfully tested and documented need not be shop tested for air-aerosol mixing uniformity. Qualification testing of sampling manifolds shall be conducted in accordance with Appendix D. Qualification testing of injection manifolds shall be performed in accordance with ASME N510, Section 9. Results of tests shall be documented and transmitted to the owner. These results shall qualify the design and installation of the sample manifolds prior to shipment. Acceptance criteria shall be as given in ASME N510. Field testing shall also be conducted in accordance with ASME N510 after installation.

5.7 Fans

5.7.1 Fan Selection. Fans shall be selected on the basis of detailed system pressure loss calculations, and shall be capable of producing the specified design flow rates. The system designer shall, in accordance with AMCA 201, prepare a system characteristic curve for design and limiting conditions under which the fans will be required to operate.

All resistances in the system, including clean and dirty component pressure drops, (as well as test pressure differential) full-open and intermediate control damper positions, duct inlet losses, and losses in ducts, housing inlets and outlets, and fan inlets and outlets shall be considered in the estimate of the system characteristics. A set of constant speed fan performance curves, showing the static or total pressure, corresponding efficiency, capacity, and brake horsepower shall be obtained from the fan manufacturer for each fan configuration. Fan inlet and discharge configurations, or other system characteristics, that would adversely alter the published fan performance shall be avoided. Fan size shall be chosen after performing an analysis of the system characteristic and fan performance curves, considering all system factors including temperature, pressure, required airflow and, particularly for fans operating in postaccident primary containment atmospheres, density and viscosity of the air or air-steam-entrained-water mixture.

Fan selection shall also allow for test conditions in accordance with ASME N510. The system designer shall identify the maximum allowable differential pressure for each filter bank plus a margin to accommodate filter loading which may occur prior to the next surveillance (typically 25% of the coincident dirty filter differential pressure). The fan and system characteristic curves shall be included in the system documentation. The fan shall be selected to operate on the stable portion of its pressure curve under all operating conditions. Provision shall be made in the design to maintain stable operation under the design flows and varying pressure range. Inlet vanes, inlet/outlet damper modulation, variable speed fan control are acceptable alternatives.

The method of fan selection, together with all pertinent data, shall be documented. Direct-drive fans are recommended for systems located inside containment. Belts, elastomeric seals, bearing lubricants, protective coatings, and other nonmetallic items and materials shall be selected to perform their required function under the environmental conditions specified in para. 4.2. Fan construction, arrangement, and other characteristics shall be established in accordance with AMCA 99. Materials and protective coatings of fan housings shall be in accordance with para. 5.6.4.

5.7.2 Rating or Test. ESF fans shall be tested in accordance with AMCA 210 and the applicable special sections of AMCA 211A. Only one fan of each size and type must be tested. Non-ESF fans shall be either rated and listed in accordance with AMCA 211A or tested the same as ESF fans. The rating or fan test shall be based on the standard test configuration most closely representative of the manner in which the fan will be installed in the nuclear air treatment system. As an alternate to the above, testing may be done in accordance with the owner's instructions to simulate, as nearly as possible, actual operating conditions that the fan(s) will be subjected to in operation. Copies of the rating report or test report shall be obtained from the fan manufacturer, together with copies [illegible] pertinent catalog data, performance data, and [illegible] and service manuals for inclusion with the d[illegible]ntation for the system. Sound ratings for the [illegible]sed on data obtained in accordance with AM[illegible]0 and reported in accordance with AMCA [illegible] shall be furnished.

5.7.3 Balancing and Vibration. Far[illegible] shall be dynamically balanced prior to final as[illegible] of the fan. Records shall be maintained in ven[illegible] file.

The double amplitude of vibration in any plane measured on the bearing cap at the rota[illegible] rotor speed shall not exceed the following:

Rotational Speed (rpm)	Double Am[illegible] (mils)
600	3.2
720	2.7
900	2.1
1200	1.6
1800	1.1
3600	0.5

Displacement may be interpolated for other speeds.

Final balancing shall be performed after fan installation is completed.

5.7.4 Drawings. Certified drawings showing outline dimensions, base or mounting dimensions, dimensional tolerances, duct connections, method or details of motor attachment, and other information necessary to install, use, and maintain the fan shall be furnished to the owner and included in the documentation. The drawings shall also show the recommended motor, belts (if any), couplings, drive units, materials of construction, protective coatings, and lubricants.

5.7.5 Documentation. A report giving a description and results of qualification tests shall be furnished to the owner. The report shall include all calculations and descriptions of any analytical or mathematical modeling techniques, a description of any computer codes used with reference to computer code validation documentation, or other tests made in conjunction with the certification or qualification of the fan or fan assembly.

5.8 Fan Drives

5.8.1 Integral Horsepower Motors — General. Motors shall comply with and be tested and rated in accordance with applicable requirements of NEMA MG-1, and IEEE 112A. Performance shall be verified by either test or certification as specified for each requirement. Rated service factor shall be a minimum of 1.0 unless specified otherwise.

Motors shall be of the type specified for the intended service. The operating characteristics to be specified shall be: voltage, frequency, operating environment including total radiation does and maximum dose rate anticipated, environmental temperature, and any identifiable special considerations such as abnormal pressures or pressure transient conditions.

Motors shall be sized to supply maximum mechanical load demand without exceeding the rated horsepower under all identified operating conditions and to produce the required torque and acceleration as required by the driven equipment under the most adverse voltage, frequency and conditions specified, and shall be designed for the starting sequence specified by the design engineer.

Bearings shall be rolling-element type and shall require lubrication no more frequently than annually under constant, normal operating conditions. Bearings shall be rated in accordance with the Anti-Friction Bearing Manufacturers' Association standard for the minimum life specified. Lubricants shall be satisfactory for the environmental conditions specified in para. 4.2.

Motors shall be equipped with thermal overload protection. Provisions to indicate bearings and winding temperatures, vibration limit switches and heaters should be considered.

Motors shall be equipped with terminal boxes of sufficient size to accommodate both motor and line leads without severe distortion of either set which might impose excess stress on the wire insulation. Terminal boxes shall be gasketed to prevent inleakage of the surrounding environment. Separate terminal boxes shall be provided for accessory equipment and instrumentation connections. All connections shall be made by the mechanical method specified. All connections shall be clearly marked or labeled to identify correct function.

Motors shall be equipped with eyes, lugs, or other lifting provisions.

Noise level shall be determined in accordance with IEEE 85.

Motor nameplates shall have, as a minimum, the information specified in NEMA MG-1.

5.8.2 Drives for ESF Systems. Drives in ESF systems shall comply with IEEE 323. In addition, drives of ESF systems located inside containment shall be qualified in accordance with IEEE 334.

ESF fan drives shall be qualified in accordance with IEEE 344. Motor supports and hangers shall be designed to withstand all seismic and operating loads with the motor in its normal operating orientation without impairment of operating characteristics.

5.8.3 Drawings and Documentation. Certified motor data sheets and dimension drawings showing major dimensions, dimensional tolerances, base or mounting dimensions, and other data needed for installation of the motor shall be furnished to the owner. Documentation specified in the IEEE standard cited in para. 5.8.2 shall also be furnished for ESF system motors.

5.9 Dampers

5.9.1 Classification. Dampers for nuclear air treatment systems, are classified by function, configuration type, construction class, and leakage class as follows.

5.9.1.1 Functions

(*a*) *Flow Control.* Varying or maintaining a flow within a nuclear air treatment system in response to a signal.

(*b*) *Pressure Control.* Varying or maintaining a pressure within a nuclear air treatment system or a space served by same in response to a signal. Also, varying or maintaining a differential pressure between parts of a nuclear air treatment system or between spaces in response to a signal.

(*c*) *Balancing.* Fixing the position of one or more dampers to establish flow or pressure relationship in a nuclear air treatment system.

(*d*) *Shutoff.* Stopping flow through some portion of a nuclear air treatment system.

(*e*) *Isolation.* Sealing a system or a portion of a system from selected flow paths.

(*f*) *Backdraft Prevention.* Preventing reversal of flow.

(*g*) *Pressure Relief.* Limiting differential pressures across a duct, casing, or building wall to a predetermined value.

5.9.1.2 Configurations

(*a*) *Parallel Blade Damper.* A multiblade damper having blades which rotate in the same direction (see AMCA 500).

(*1*) With centrally pivoted balanced blades.

(*2*) With eccentrically pivoted or edge-pivoted blades.

(*b*) *Opposed Blade Damper.* A multiblade damper having blades which rotate in opposite directions (see AMCA 500).

(*c*) *Butterfly Valve.* A valve with one centrally pivoted balanced blade, designed for high pressure (25 psi minimum rating) and which meets the requirements of Construction Class A.

(*d*) *Single Blade Damper.* A damper having one blade.

(*1*) With a centrally pivoted balanced blade.

(*2*) With an eccentrically pivoted or edge-pivoted blade.

(*e*) *Wing Blade Damper.* A damper with two blades eccentrically pivoted or pivoted from a central post.

(*f*) *Poppet Damper.* A single blade damper with linear blade motion which is always perpendicular to the seat.

(*g*) *Slide Gate Damper.* A damper with one or two blades which move in, and are supported by, parallel guides.

5.9.1.3 Construction

(*a*) Class A meets ANSI B31.1.

(*b*) Class B meets para. 5.9.3.2.

5.9.1.4 Leakage Class

(*a* Class I, bubble tight as determined by the test of para. 5.9.7.3.

(*b*) Class II, Maximum leakage as specified in Table 5-3.

(*c*) Class III, Maximum leakage as specified in Table 5-3.

(*d*) Class IV, leakage not a consideration.

5.9.2 Design Considerations. The following supplemental parameters shall be considered for each damper when establishing design requirements in addition to those delineated in para. 4.2:

(*a*) function of damper

(*b*) configuration

(*c*) construction classification

(*d*) leakage classification

(*e*) dimensions and space required for installation and service

(*f*) maximum pressure differential across closed damper

(*g*) maximum pressure drop across wide-open damper at rated airflow, in. w.g.

(*h* air stream and ambient temperature range

(*i*) normal operating position of blades

(*j*) damper orientation (horizontal or vertical) and method of mounting and direction of air flow

(*k*) blade orientation relative to frame of damper

(*l*) failure position

(*m*) operator type, power source

(*n*) maximum closure or opening time

(*o*) seismic requirements

(*p*) shaft sealing

(*q*) bearings and lubrication

(*r*) position indication, limit switches and other options

Recommended damper minimum requirements for leakage and construction are given in [illegible] Maximum permissible damper leak rates for [illegible] II and III are shown in Table 5-3. Table 5-4 [illegible] multipliers for obtaining maximum perm[illegible] leakage rates when dampers are tested at higher [illegible]ures.

5.9.3 Design Requirements. Damp[illegible] shall be constructed to meet the applicable design considerations within the following requirements.

5.9.3.1 Construction Class A. Construction Class A dampers meet the requirements for valves of ANSI/ASME B31.1.

5.9.3.2 Construction Class B. Construction Class B dampers shall be industrial quality construction: all parts, including frame, blades, pivots, shafts, bearings, linkages, and operators, shall be designed to the following minimum criteria.

(*a*) *Frame.* Frames shall be rolled, formed, or fabricated into a channel shape having a minimum width of 4 in., minimum flange height of 1½ in., and a minimum thickness of ⅛ in.

Frame deflection under design loadings shall not exceed $1/360$ of the span in any direction.

TABLE 5-2 DAMPER CLASSIFICATION FOR CONSTRUCTION AND LEAKAGE

Function of Damper [Note (1)]	Construction Class [Note (2)]	Leakage Class [Note (3)]
Flow control	B	III
Pressure control	B	III
Balancing	B	IV
Shutoff		
(a) Contaminated air stream	A,B	I
(b) Noncontaminated air stream [Note (4)]	B	II
Isolation		
(a) Contaminated air stream	A,B	I
(b) Noncontaminated air stream [Note (4)]	B	II
Backdraft prevention		
(a) Contaminated air stream	B,A	I,II
(b) Noncontaminated air stream [Note (4)]	B	II
Pressure relief	B	II

NOTES:
(1) Where a damper serves more than one function, for example, flow control and shutoff, then the more stringent leak class governs.
(2) Refer to para. 5.9.1.3.
(3) Refer to para. 5.9.1.4.
(4) Where the calculated biological effects on complete damper failure are within governmental guidelines for continuous exposure, the air stream may be considered noncontaminated.

TABLE 5-3 MAXIMUM PERMISSIBLE DAMPER LEAK RATE, CLASS II AND III

Damper Blade Length or Diameter, in.	Maximum Permissible Leak Rate scfm/sq ft of Damper Face Area, at 1 in. w.g. Differential Pressure [Note (1)]	
	Leakage Class II	Leakage Class III
12	15	60
24	10	40
36	8	32
48	8	32

NOTE:
(1) Interpolation may be used for other blade lengths. Extrapolation is not recommended.

TABLE 5-4 MULTIPLYING FACTORS FOR OBTAINING MAXIMUM PERMISSIBLE LEAKAGE RATES AT HIGHER PRESSURES

Differential Pressure, in. w.g.	Multiplier [Note (1)]
2	1.4
3	1.7
4	2.0
5	2.2
6	2.4
7	2.6
8	2.8
9	3.0
10	3.2
11	3.3
12	3.5

NOTE:
(1) Multiplier = (differential pressure, in. w.g.)$^{1/2}$ which is applied to leakage noted in Table 5-3.

Duct-mounted dampers should have predrilled mounting flanges, and should be designed for mounting between flanged sections of ductwork. Balancing dampers may be designed for flanged or slip-in mounting.

(*b*) *Blade and Shaft.* Blade edge and shaft deflection shall not exceed $\frac{1}{360}$ of span or $\frac{1}{8}$ in., whichever is less, under the forces produced by operation of the damper at 1.5 times the design conditions for flow and pressure, and shall not cause the leakage criteria to be exceeded. Shafts shall be solid and extend the full blade length with minimum diameters of $\frac{3}{4}$ in., except dampers smaller than 19 in. by 19 in. may be designed with minimum shaft diameter of $\frac{1}{2}$ in. Blades shall be welded or through bolted to the shaft in such a manner that the integrity of the attachment can be verified.

Minimum blade thickness shall be 16 gage (0.059 in.) and 18 gage (0.047 in.) for single and double thickness steel blades, respectively.

Blade and edge seals shall be radiation and corrosion resistant.

(*c*) *Linkage.* Linkage should be located outside of the air stream, and component design shall include at least the following minimum requirements.

(*1*) Brackets, arms, and levers shall be of sufficient length and stiffness to provide stable operation of the damper blades without flutter or binding, at all blade positions.

(*2*) The linkage system shall be designed to deliver sufficient torque to each blade to properly set the seals of each and every blade.

(*3*) All linkage components shall be designed to transmit the required torque without exceeding the maximum stresses listed in para. 5.10.3.3. The required torque shall be defined as twice that portion of the damper torque the component is expected to transmit or the maximum actuator torque capability when the component may be required to transmit the full torque capability of the actuator.

(*d*) *Bearings.* Bearings shall be flange-mounted, lubricant impregnated, sintered bronze type or rolling element type for temperatures of 200 °F or less. Dampers which must be operable in temperatures exceeding 200 °F shall have external rolling element type bearings. All rolling element bearings shall be provided with grease fitting for lubrication. Bearings for vertically oriented blades shall be designed for thrust loads.

(*e*) *Stress.* Allowable stress for frames, blades, shafts, and linkage shall be in accordance with para. 5.10.3.3.

5.9.4 Welding. Welding of Construction Class A dampers shall comply with the requirements of ANSI/ASME B31.1. Welding of Construction Class B dampers shall comply with para. 7.3.

5.9.5 Operators. Operators should be located outside of the air stream and should be mounted by the damper manufacturer. Operator torque requirements shall be specified by the damper manufacturer. Operators shall be designed to provide a minimum of 1.5 times the torque to meet specified maximum leak rate requirements or design requirements, whichever are greater. Electric powered operators, solenoid valves, and limit switches used in ESF systems shall be qualified to meet the requirements of IEEE 323 and IEEE 334. Position locking devices shall be provided on balancing damper manual operators.

5.9.6 Position Indicators. Dampers with external rotating shafts shall have a mechanical position indicating arm and escutcheon plate; dampers which will be remotely indicated shall also have the necessary switches, relays, or other devices necessary to meet the requirements of para. 4.8. Electrical switches used for remote indication of the damper position in an ESF system which are specified to perform additional safety-related functions shall be required to meet the requirements of IEEE 323.

5.9.7 Tests

5.9.7.1 Qualification Tests. Flow characteristics and pressure drop for dampers shall be determined in accordance with AMCA 500. Leakage rates for Leakage Class I shall be determined by the method described in para. 5.9.7.3. Leakage rates for Leakage Classes II land III shall be determined in accordance with AMCA 500. Copies of test reports for Leakage Classes I and II shall be furnished to the owner; copies of test reports for Leakage Class III shall be furnished to the owner when specified. Listing of Leakage Class II and III dampers in the Directory of Products Licensed to Bear the AMCA Certified Rating Seal, current edition, shall be evidence of meeting the qualification test requirements.

5.9.7.2 Shop Tests. Each damper (except manual balancing dampers) and its accessories shall be cycled at least 10 times from the full-open to the full-closed position to check the free operation of all parts and correct adjustment, positioning and seating of blades. On completion of cycling, the alignment shall be reworked, if necessary, to correct deficiencies before shipment. When shop leakage tests are required, they shall be performed after the cycling test and after the deficiencies have been corrected.

5.9.7.3 Bubble Test. The following test shall be conducted on each leakage Class I damper assembly. The damper assembly shall be bolted to a sealed chamber which is then pressurized to the specified pressure; there shall be no bubbles when tested with a soap solution in accordance with the Bubble Method of leak detection in ASME N510-1989.

5.9.8 Reports

The manufacturer shall furnish the following items to the owner:

(*a*) pressure drop, in. w.g., at design airflow capacity, with AMCA 500 apparatus setup figure;

(*b*) air leakage rate, cfm/ft^2, in full-closed position at specified pressure differential, and torque with AMCA 500 apparatus setup figure;

(*c*) maximum torque required by damper, ft-lb;

(*d*) operator torque available in position corresponding to maximum damper torque;

(*e*) shop leak test report when required;

(*f*) IEEE qualification reports on electric-powered operators and electric accessories.

All reports, data, and manuals furnished by the manufacturer shall be marked to show the manufacturer's name and damper identification.

5.9.9 Drawings. Certified Drawings showing the general arrangement and principal dimensions of the equipment including operators and accessories, and cross sections through the equipment shall be submitted to the owner. This shall include size, type, and location of all support connections.

All drawings shall properly dimension and locate the position of the operator in three directions to permit verification of adequate clearance and access for maintenance. Each drawing shall include all damper unique performance and design parameters such as failure mode, leakage, and torque requirements, etc.

Certified copies of manufacturer's outline prints of electrical control equipment, wiring diagrams, and schematic diagrams covering all electrical equipment that is factory-wired shall be submitted to the owner.

Drawings of mechanical components of control equipment (if any), including diagrammatic layouts of the control system shall also be submitted to the owner.

Drawings shall contain details of damper linkage, coupling between damper shaft and operator, attachment of damper blade to shaft and attachment of damper seals.

5.9.10 Preparation for Shipping. Dampers shall be prepared for shipment in accordance with para. 6.1.

5.9.11 Coatings. Coatings shall be in accordance with para. 5.6.4.

5.10 Ducts

5.10.1 General. The duct system shall be designed and constructed to meet the structural and pressure loading and leaktightness of Section 4, while transporting a possibly contaminated or treated air or gas stream from the point(s) of collection to the point(s) of intersection with plant ventilation system or discharge to a plant vent stack.

5.10.2 Design Considerations. The following supplemental parameters shall be considered for the duct system when establishing design requirements in addition to those delineated in paras. 4.2, 4.4, 4.5, and 4.6:

(*a*) duct size

(*b*) methods of support

(*c*) system operating pressure

5.10.3 Structural Requirements

5.10.3.1 General. Transverse joints and longitudinal seams shall be designed to retain their structural and sealing integrity when subject to the design loads.

5.10.3.2 Loadings. Stresses and deflections, or charts used to determine them, shall be based on calculations that consider the following loads where applicable.

(*a*) Differential pressure across the duct wall as affected by:

(*1*) maximum positive or negative pressure during all conditions of operation accounting for possible damper positions;

(*2*) pressure transients due to:

(*a*) pipe breaks, including both postulated Loss-of-Coolant Accident (LOCA) and lesser pipe break incidents which may cause external pressure rises and/or internal pressure pulses originating in sections of duct with openings in possible pipe break areas;

(*b*) extreme wind conditions, including tornado, hurricane;

(*c*) rapid damper, plenum door, or valve closure;

(*b*) duct weight, including insulation;

(*c*) duct sections with exposed top surfaces, which could be used as a walkway or crawl space, shall be capable of supporting a 250 lb weight concentrated midway between hangers;

(*d*) seismic forces;

(*e*) thermal expansion.

5.10.3.3 Stress. Allowable stress shall be 0.6 of the yield stress for loads encountered during normal plant operation and shutdown, and shall be 0.9 of the yield stress for combined loads which include the Safe Shutdown Earthquake and Design Basis Tornado.

5.10.3.4 Static Deflection. Allowable static deflections shall not exceed the following values:

(*a*) plate or sheet: $\frac{1}{8}$ in. per ft of the maximum unsupported panel span in direction of airflow but not more than $\frac{3}{4}$ in. relative to stiffeners;

(*b*) stiffeners and flange connections: $\frac{1}{8}$ in. per ft of span but not more than $\frac{3}{4}$ in;

(*c*) flange connection to dampers and fans: $\frac{1}{360}$ of the span or $\frac{1}{8}$ in. maximum.

5.10.4 Duct Construction. Transverse joints shall be gasketed flange, seal-welded flange, or butt-welded. Longitudinal seams shall be either all-welded, seal-welded mechanical, or in accordance with SMACNA — High Pressure Duct Construction Standards (Pittsburgh Lock or ASME Lock Seam) as required to meet structural and leaktightness requirements of paras. 5.10.3 and 4.14, respectively.

Mechanical lock seams, if used, must meet seismic structural design requirements. For all-welded joints, the minimum duct thickness shall be 18 gauge (0.047 in.) to ensure reliability of the weld. Turning vanes, where used, shall be reinforced and fastened to the duct elbow by welding to withstand the loading specified. Radius elbows, where used, should have a minimum centering radius of 1.0 times the width or diameter of the duct in the plane of the bend.

Placement and design of hangers and supports shall meet the stress criteria given in para. 5.10.3.3 when considering the sources of load given in para. 5.10.3.2.

Stiffeners shall be of sufficient size and quantity and welded to the duct to meet the structural requirements of para. 5.10.3. Stiffener materials shall be compatible with the material of the duct.

Supports shall be formed of fabricated structural members of a material compatible with the duct and stiffeners. Supports shall be securely fastened to building members by welding or by the [illegible] bolts. Supports shall be fastened to the duct or stiffeners in accordance with the structural requirem[illegible]

Accessories shall be provided, as req[illegible] for the termination of the duct at outlets and [illegible]ccess doors shall be provided for inspection [illegible] maintenance of devices mounted inside the [illegible]cess doors shall be designed and installed to m[illegible] leakage in accordance with the allowable lea[illegible] para. 4.14.

Duct ends of flexible connectors shal[illegible]ted and positioned such that they do not [illegible] the fabric.

5.10.5 Welding. Welding shall be [illegible]ance with para. 7.3.

5.10.6 Materials. Ducts may be fab[illegible] from stainless steel, carbon steel, galvanized [illegible] sheet, plate, pipe, or rolled structural sections[illegible]ctural members may be fabricated from plain or galvanized carbon steel.

Stainless steel shall conform to ASTM A 666 or ASTM A 240. Carbon steel shall conform to ASTM A 36 for structural shapes or ASTM A 283 Grade [illegible] or D. or ASTM A 284 Grade C or D for plate. Carbon steel shall be hot-rolled pickled and oiled per ASTM A 570, or hot-rolled pickled and oiled, or cold-rolled per ASTM A 606 or A 607. Galvanized steel shall be in accordance with ASTM A 526 or A 527, coated to ASTM A 525, Coating Designation G90.

Use of nonmetallic materials in fabrication or installation of ducts and duct components shall, in addition to considerations of allowable stress, be based on resistance to deterioration from contaminants, heat, pressure, and radiation, and shall not support combustion.

5.10.7 Coatings. Coatings shall be in accordance with para. 5.6.4.

5.10.8 Testing

5.10.8.1 Air Leakage Test. Except where excluded below, duct sections shall be subjected to air leak tests as described in ASME N510-1989 using the criteria given in para. 4.14.

A duct section need not be subjected to quantitative measurement of leakage if one of the following conditions is satisfied. However, a procedure to pressurize the system and locate and seal all audible leaks shall be applied.

(*a*) All ESF and non-ESF ducts serving the protected space, are located within the protected space, regardless of length.

(*b*) All negative pressure ESF and non-ESF ducts that pass through clean interspace.

(*c*) All positive pressure ESF and non-ESF ducts that pass through contaminated interspace with an MPC within the duct (C_d) less than or equal to 1.1 times the room MPC (C_r):

$$C_d \leq 1.1\ C_r \qquad (2)$$

(*d*) Non-ESF and ESF positive pressure ducts that pass through a "Clean Interspace," and the effective concentration within the duct is less than 5 MPC.

(*e*) Non-ESF and ESF negative pressure ducts that pass through a contaminated interspace with an MPC (C_r) that is no greater than 1.1 times the MPC within the duct (C_d):

$$C_r \leq 1.1\ (C_d) \qquad (3)$$

(*f*) All plant vent stacks or ducts that are located outside plant buildings and no high-level or mixed-mode release credit is required to meet offsite dose limits.

5.10.8.2 Structural Capability Test. A pressure test shall be performed on those portions of ducts and housings of once-through and recirculation nuclear air treatment systems which could be subjected to fan peak pressure due to closure of dampers on suction or discharge of fan. The test shall be performed at the structural capability pressure established in para. 4.6.6. When duct construction is greater than SMACNA-recommended duct construction for the maximum design pressure, then Structural Capability testing is not required. If required, ducts shall be tested in accordance with Structural Capability pressure test of ASME N510. Upon completion of the pressure test, ductwork exhibiting permanent distortion or breach of integrity shall be repaired or replaced. The pressure test shall be repeated after repairs until no permanent distortion or breach of integrity is observed.

5.10.9 Balancing. Prior to declaring the nuclear air treatment system operable, all duct systems shall be balanced to achieve design flow rate at the fan(s) and to maintain spaces at the required pressure differential. Upper and lower flow limits shall be established by owner such that design function of the system is maintained and equipment capabilities are not exceeded.

6 PACKAGING, SHIPPING, RECEIVING, STORAGE AND HANDLING OF COMPONENTS

6.1 Preparation for Shipping

Adsorber cells (Type I or II) shall be prepared for shipping in accordance with applicable Sections of ANSI/ASME AG-1-1988. Prefilters and after filters shall be packaged in accordance with manufacturer's standard practice. Moisture separators, HEPA filters, heaters, Type III adsorbers, motors, fans, and dampers should be packaged in accordance with ANSI/ASME NQA-2-1986 (level as appropriate for each component) and shall be crated or skidded, or both, in a manner that will protect the item from physical damage and exposure to dirt, weather (including road spatter), and vibration during shipment and subsequent storage at the installation site for conditions in para. 4.2 of this Standard. Housing openings larger than 6 in. shall be covered with weather resistant panels thick enough, or reinforced sufficiently to limit deflection to less than one-half of the panel thickness under a pressure of 3 in. w.g. Panels shall be bolted to flanges or otherwise attached so they cannot be torn loose during shipping. Openings 6 in. in diameter and smaller shall be sealed or capped with plastic plugs. Unpainted carbon steel surfaces shall be coated with a rust inhibitor before packaging.

6.2 Receipt and Storage

HEPA filters and adsorbers should be stored in their original cartons in an environmentally controlled room. HEPA filters shall be oriented vertically with their pleats vertical, and be stacked no more than three cartons (slightly over 6 ft) high unless intermediate bracing or flooring is provided to prevent the weight of the upper tier from bearing on the lower tier. Tray type (Type II) adsorber cells shall be stored horizontally and stacked no more than 5 high unless intermediate bracing or flooring is provided. Unless there is obvious damage to the cartons, HEPA filter and adsorber cartons should not be opened prior to use, or removed from shipping pallets or skids until immediately ready for installation. Adsorbent shall be packaged, and stored in accordance with ANSI/ASME AG-1 Section FE.

Where possible, items such as motors, dampers, heaters, etc., should be stored on racks or platforms, off the floor. While in storage, items should be checked periodically (weekly recommended) to ensure that wrappings are not disturbed. Storage areas should be uncluttered and permit easy access to items without the necessity of moving other items to get to them. An item-control procedure should be established in the storage area to ensure that items are not removed from the area without proper authority, and to prevent improper or rejected items from being installed in the system. Materials and components shall be moved and handled in a manner that does not damage the item or its packaging. If plugs, caps, or wrappings are removed for receiving inspection, they shall be replaced and positively sealed immediately upon completion of the inspection. Receiving and storage personnel shall be informed of the necessity of proper handling of all components, especially the HEPA filters and carbon adsorber cells.

7 INSTALLATION AND ERECTION

7.1 Drawings

Complete system layout drawings showing the location of housings, ducts, fans, dampers, and the other external components in each of three mutually perpendicular planes shall be prepared prior to the start of erection. Drawings shall show all connections, hangers, and anchors, the location and joint details for all welds, and the procedure specification for each weld. The layout drawings shall reference dimension and shop drawings of components, as applicable. Layout shall be checked for interferences with other items to be installed in the area, and conflicts shall be resolved before installation.

7.2 Erection

All ducts, housings, fans, dampers, hangers, anchors, and services (electrical, steam, drains, etc.) shall be installed in strict conformance with the layout drawings; deviations of more than the design tolerance from the location in any plane from the position shown in the drawings shall be approved by the system designer or other responsible engineer, and shall be documented by "as-built drawings." Prefabricated duct subassemblies should be made as large as practicable to minimize field joints and field welding. Housings shall not be used to support other equipment of the facility for which it was not designed; field runs of pipe, duct, or conduit or other systems of the facility shall not be permitted to penetrate the housing. Internal components (filters, adsorbers, etc.) shall not be installed until immediately before the system is presented for testing, and shall not be removed from their cartons or crates until they are ready to be installed. The recommendations for handling and installation of HEPA filters given in Appendix C of ERDA [illegible] shall be complied with.

7.3 Welding

Welding procedures, welders, and we[illegible] operators shall be qualified in accordance [illegible] ANSI/ASME AG-1-1988. For material thic[illegible] greater than or equal to 0.125 in., AWS D1.1 o[illegible] Section IX shall be used. For material thic[illegible] than 0.125 in., AWS D1.3 shall be used. Per[illegible] qualification test samples for materials used [illegible] housing pressure boundary construction sha[illegible] ected with liquid penetrant or magnetic par[illegible] both root and face surfaces in accordance wi[illegible] on 6, Part I of AWS D1.1 or ASME Boiler [illegible] essure Vessel Code, Section V. Liquid penetran[illegible] inside containment shall have a low chloride [illegible] ide content. Production welds shall be visually [illegible] cted in accordance with AWS D1.1, AWS D[illegible] ASME BPVC Section IX as applicable. Accep[illegible] criteria for welds produced to AWS D1.1 standar[illegible] hall be per NCIG-01. Acceptance criteria for welds produced per AWS D1.3 shall be in accordance with that standard. Acceptance criteria for welds produced per ASME BPVC Section IX shall be in accordance with the applicable ASME design section of the Code, except that visual acceptance criteria per NCIG-01 may be utilized for those components which are not required to be fabricated to a specific ASME design section of the Code.

7.4 Installation of HEPA Filters and Adsorbers

Installation personnel shall be instructed in the proper handling of the HEPA filters and carbon cell adsorbers prior to the installation and clamping of the filters.

Components should not be removed from protective cartons, crates, pallets, or skids until immediately before they are to be installed. Each item should be checked for physical damage, corrosion, or evidence of abuse. Replace or repair damaged items before use. The position and alignment of foundations, anchors, hangers, ducts, housings, dampers, fans, motors, and other components shall be checked and their locations shall be within tolerance as shown on the drawings. Pleats of HEPA filters shall be vertical, gaskets of HEPA filters and adsorbers shall be securely affixed so that they are not displaced during installation. Clamping devices shall be in place and completely tightened to produce the required gasket compression.

After filters and adsorbers are unpacked and opened to the atmosphere, extreme care is required to ensure that degradation does not occur either from exposure before loading or by system operation during testing, construction, repair, or plant modification. Prefilters and HEPAs are particularly vulnerable to degradation due to construction dust. If additional welding is required on the filter housing after HEPA filters or adsorbent is installed, the HEPA filters and adsorbent must be removed before starting this work. HEPA filters are very susceptible to pinholes from welding sparks. Carbon adsorbent is aged or poisoned by trace concentrations of vapors such as solvents, paint off-gassing, engine exhaust and welding fumes, or by moisture condensation.

8 QUALITY ASSURANCE

8.1 Quality Assurance Program

The design organization, manufacturers of components, and constructors (including subcontractors) shall each establish and comply with a comprehensive quality assurance program and plan which meets the requirements of ANSI/ASME NQA-1-1986.

8.2 Summary of Required Documentation

As a minimum, the following shall be documented and submitted to the owner:

Documentation	Ref. Paragraph
Design Parameters	4.2
Maximum Operating Pressure	4.6
Test Pressure	4.6
Structural Capability Pressure	4.6
Test Cannister Qualification	4.11
Basis and Quantity for Maximum Allowable Leakage	4.14
HEPA Filter Qualification Report	5.1.3
Adsorber Drawings and Qualification Report	5.2.4/5.2.5
Prefilter and Postfilter Qualification Reports	5.4.1
Moisture Separator Drawings and Qualification Report	5.4.1/5.4.2
Heater Drawings and Qualification Report	5.5.2/5.5.4
Housing Drawings	5.6.2(g)
HEPA and Adsorber Clamping Device Drawings	5.6.3
Manifold Drawings	5.6.5.1
Factory Visual Inspection Reports	5.6.5.2
Factory Housing Leak Test Results	5.6.5.4
Factory Airflow Distribution Test Results	5.6.5.5
Factory Air-Aerosol Mixing Uniformity Test Results	5.6.5.6
Fan Drawings and Qualification Test Report	5.7.4/5.7.5
Fan Motor Drawings and Data Sheets	5.8.3
Damper Drawings and Reports	5.9.8
Test Acceptance Criteria	Table 9-1
System Layout Drawings	7.1

9 ACCEPTANCE TESTING

Acceptance tests shall be made in accordance with the procedures of ASME N510. It is recommended that prefilters be installed before fan is first turned on to protect filters and fans from construction debris, and the system fan(s) should be operated for at least 24 hr before installation of HEPA filters and adsorbers to clean up the worst of construction dirt (artificial resistance may have to be added during this operation to prevent overloading of the fan motor). Prefilters may have to be replaced after this. For personnel protection, personnel should not enter housing until fan has operated for a sufficient period of time to remove air entrainable debris. After installing the HEPA filters and adsorbers, the system heaters should be operated, where provided, to reduce, if necessary, the relative humidity of the air prior to making tests on the adsorbers.

All dampers, valves, and controls shall be exercised through their full operating range and shown to be in good operating condition before the start of testing. After completion of acceptance testing, the system shall be sealed and the fan controls locked out to protect the components during the remainder of construction operations at the site.

The system designer (engineer) shall provide the acceptance criteria in Table 9-1 to the owner to incorporate in his acceptance and surveillance test procedure and project specification in accordance with ASME N510 requirements.

TABLE 9-1 SUMMARY OF CRITERIA FOR ACCEPTANCE TESTING

N510 Test	N510 Section	Information and Acceptance Criteria Provided by System Engineer	N509 Reference
Visual Inspection	5	None required from system engineer	5.6.5.2
Housing Leak Test	6	Test pressure(s) and tolerance	4.6.4
		Maximum allowable leakage at test	4.14, 4.2
		pressure boundary to be tested	
Mounting Frame Leak Test	7	Identification of frames to be tested	5.6.5.3
		Test pressure(s) and tolerance	4.6.4
		Maximum allowable leakage	4.14
Duct Leak Test	6	Boundaries to be tested, applicable test pressure (and tolerance), and maximum allowable leakage	4.14, 4.2, 4.[illegible]
		Justification for duct test exceptions	5.10.8
Airflow Capacity and Distribution	8	Required minimum design airflow rate for each operating mode	4.14, 4.2
		Maximum allowable airflow rate	4.14, 4.2
		Design flow rate	4.2
		Minimum filter housing pressure drop with clean filter components and test pressure tolerance	4.2
		Maximum filter housing pressure drop with coincident dirty filter pressure drop and test pressure tolerance	4.2
Air-Aerosol Mixing Uniformity	9	Design airflow rate	4.2
In-Place HEPA Leak Test	10	Design airflow rate	4.2
		Maximum (dirty) and minimum (clean) filter bank pressure drop	4.2
		Maximum allowable penetration	PSAR/FSAR Technical Specification
In-Place Adsorber Leak Test	11	Design airflow rate	4.2
		Maximum allowable penetration	PSAR/FSAR Technical Specification

TABLE 9-1 SUMMARY OF CRITERIA FOR ACCEPTANCE TESTING (CONT'D)

N510 Test	N510 Section	Information and Acceptance Criteria Provided by System Engineer	N509 Reference
Duct Damper Bypass Test	12	Test boundary to be tested	4.14
		Design airflow rate	4.2
		Operating pressure differential across damper	4.6
		Maximum allowable penetration	4.14
System Bypass Test	13	Test boundary to be tested	4.14
		Design airflow rate	4.2
		Operating pressure differential	4.6
		Maximum allowable penetration	4.14
Air Heater Performance Test	14	Design airflow rate	4.2
		Design capacity	4.2
		Design temperature differential (leaving temperature — entering)	4.2
		Design current (amps), each circuit at design voltage	5.5
Laboratory Testing of Adsorbent	15	Design airflow rate	4.2
		Bed thickness	4.2, 5.2
		Design velocity	4.14, 5.2
		Minimum residence time	PSAR/FSAR/Technical Specification
		Test conditions	PSAR/FSAR/Technical Specification
		Maximum allowable penetration	PSAR/FSAR/Technical Specification

MANDATORY APPENDIX A
SAMPLING OF INSTALLED ADSORBENTS FOR SURVEILLANCE TESTING

(This Appendix is an integral part of ASME N509-1989, and is placed after the main text for convenience.)

A1 SCOPE

Provision shall be made to periodically remove a representative sample of adsorbent from an installed system for Surveillance Tests.

A representative sample is defined as one that has experienced flow within ±20% of the average flow of the system (as confirmed by testing per Section 8 of ASME N510-1989). The detailed means to achieve this is left to the designer of each system, but detailed supporting data (either theoretical or empirical) shall be presented to substantiate that the flow is representative and the sample is, therefore, representative of the entire adsorber bank.

A2 DESIGN BASIS FOR SAMPLERS

For the sample to be representative, it shall have experienced the same exposure to all contaminants as the entire bed it represents. To accomplish this, it shall have experienced the same flow (±20%) during the same period. This criterion can be met only when the bed depth and pressure drop through a sampler section are the same as through the main adsorber bank. All flow restrictions must be taken into account when designing a sampler. Pipe stubs, valves, unions, fittings, elbows, nozzle effects, and similar items or effects add pressure drop to the flow path and tend to make a sampler non-representative. This Standard does not restrict any specific approach or hardware but stresses that the flow criterion for equal bed thickness must be met.

A3 GENERAL TYPES OF SAMPLES (SAMPLERS)

A3.1 Individual Samplers

A special adsorbent sample holder should be designed to hold adsorbent for testing. It shall be the same depth as the main bed, a minimum of 2 in. in diameter and in the same orientation as the main bed. If there is a guard bed it shall be duplicated for the sampler.

The sampler shall be filled with adsorbent from the same lot and batch as the main bed.

Each sampler shall have at least the following data attached:

(*a*) serial number
(*b*) adsorbent lot and batch number
(*c*) adsorbent manufacturer and type
(*d*) installation date
(*e*) system where installed

The details of sampler design shall inclu[illegible]d to ensure that no bypass will occur, that [illegible]er(s) will be halide leak tested along with the [illegible] per Section 11 of ASME N510 as part o[illegible]ated filter bank leak test, and that the flow [illegible]ll be sealed leaktight after the sampler is rem[illegible]nsideration should be given in the design to [illegible]ertion of the sampler into a laboratory test [illegible] for determination of methyl iodide penet[illegible] without disturbing any of the adsorbent.

A3.2 Test Tray Assemblies

A *test tray assembly* is an adsorber cell [illegible] to provide for removal of a portion of the adsorbent (usually one-eighth) without disturbing the remainder of the adsorbent. Its use is acceptable as an alternative to individual samplers described in Section A3.1 of this Appendix for obtaining representative samples.

When a test tray assembly is removed, an entire section is emptied into a clean plastic container or bag, mixed to ensure uniformity, a sample taken, and the section refilled with such makeup adsorbent as required. This makeup carbon shall meet the same requirements as the original adsorbent.

The section sampled shall be marked to indicate when a sample was taken and the section number and position noted both in the field test report and permanent plant records to ensure that this section is not used again.

Each cover plate shall be permanently marked with a unique identification symbol.

Each test tray assembly shall have at least the following data attached:

(*a*) serial number
(*b*) adsorbent lot and batch number
(*c*) adsorbent manufacturer and type
(*d*) installation date
(*e*) system where installed

A3.3 Sampling by Adsorber Cell Removal

As a further alternative, an entire adsorber cell or bed may be removed to obtain a sample. It shall be emptied into a clean plastic container or bag, the adsorbent mixed to ensure uniformity, a sample taken, the cell refilled or replaced. If the adsorber cell is refilled it shall be marked as having been refilled and shall not be used for future samples as they are not representative of the adsorbent in the rest of the bank.

A3.4 Slotted-Tube Sampling

For Type III adsorbers, where the adsorbent bed is refilled in-place, a sample may be taken with a slotted-tube sampler if sufficient test cannisters are not available. ASTM E 300 contains slotted-tube sampler details and background. For systems where the adsorbent bed thickness is 2 in. deep, insert the slotted-tube sampler into the bed far enough to ensure that the sample will be taken from an area where flow is experienced by the adsorbent. For systems where the adsorbent bed thickness is greater than 2 in., the position where the slotted-tube sampler is inserted into the bed is important. When a single sample representative of the entire bed is desired, the slotted-tube sampler should be inserted at an angle to pick up carbon from both the inlet and outlet faces of the bed. No carbon should be taken from areas of less than full flow. When separate samples form inlet and outlet faces are desired, sample positions should be noted and the separate samples should not be mixed. When separate samples are taken, it may be required to calculate a composite efficiency for the bed.

NONMANDATORY APPENDIX B
Additional Guidance for Determination of Allowable Leakage

(This Appendix is not part of ASME N509-1989, and is included for information purposes only.)

B1 PURPOSE

The purpose of this Appendix B is to provide additional guidance for a system owner or designer to determine allowable leakage for nuclear air treatment systems that can be used to determine design, fabrication, installation, and test requirements.

This Appendix examines a method for determining allowable leakage based on health physics requirements (such as radioactivity concentration, maximum permissible concentration, and iodine protection factor) and provides typical example problems.

In addition, optional guidance is provided to assist an owner or system designer to determine additional leakage criteria based on prescribing a system effectiveness tolerance, or representative system installation quality.

B2 ALLOWABLE LEAKAGE BY HEALTH PHYSICS CRITERIA

B2.1 General

10 CFR 20, Appendix B, Table 1 sets limits on airborne radioactive concentrations in areas of the nuclear power plant in which plant personnel may be present.

This section also provides procedures to determine maximum duct outleakage based on the maximum permissible concentration (MPC) as determined by 10 CFR 20.103, paragraphs a and b.

B2.2 Procedure to Determine Allowable Leakage by MPC Method

(*a*) The following describes a procedure for determining allowable leakage in cfm/ft² of positive pressure duct surfaces in either normal or transient conditions:

(*1*) Determine approximate radioactivity concentration C_d in MPCs expected inside the duct.

(*2*) Determine approximate radioactivity concentration C_r in MPCs that can be expected in the room. For continuous occupancy C_r must be less than 1.

(*3*) Enter Fig. B-1 with C_r/C_d ratio and determine allowable unit leakage, cfm/ft² duct surface. The value taken from the chart will be applicable at the operating pressure.

Nomenclature

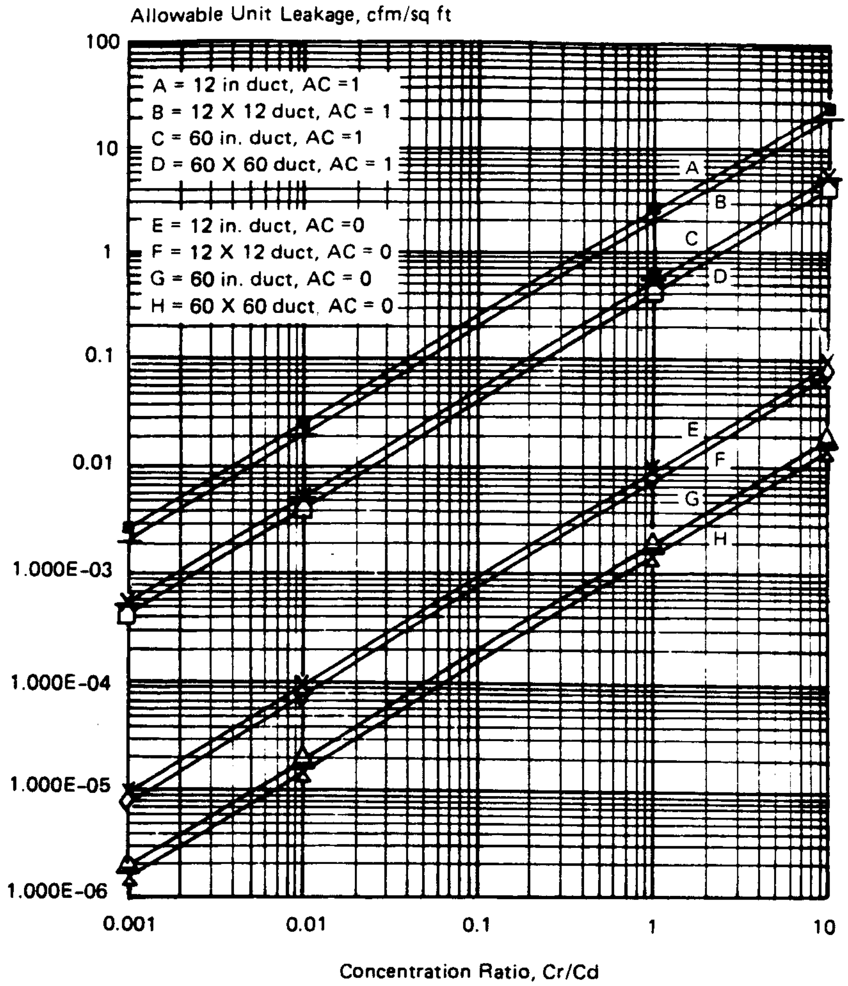
L = allowable duct leakage per unit duct surface area, cfm/ft²
A = duct surface area, ft²
h = duct height, in.
b = duct width, in.
ld = duct length, ft
D = duct diameter, in.
l = room length, ft
W = room width, ft
H = room height, ft
Vr = room volume, ft³
$\overline{A}C$ = room ventilation rate, air changes per hr or $60\, qv/(Hlw)$
qv = room ventilation rate, cfm
C_r = radioactivity concentration in room, μCi/cc
C_d = radioactivity concentration in duct, μCi/cc
G = contamination source term, μCi/hr
$T^{1/2}$ = nuclide half life, hr
λ = radioactivity decay constant, hr^{-1}
MPC = maximum permissible concentrations

Duct to room contamination source term:

$$G = 1.7 \times 10^6\, C_d\, LA \qquad \text{(B1)}$$

Equilibrium concentration in the room which results from outleakage is:

$$C_r = \frac{G}{28320\, Vr\left(\lambda + \dfrac{60\, qv}{Vr}\right)} \qquad \text{(B2)}$$



GENERAL NOTES:

(a) Based on eq. (B-1) in para. B.2.1(d) and a 25 sq ft room X 20 ft high. For other duct (and room) lengths and heights, prorate chart values by

$$L = L_{\text{chart}} \times \frac{\text{duct length}}{25} \times \frac{\text{room height}}{20}$$

(b) Contamination assumed to mix uniformly in space.

(c) 1-131 assumed to be contaminating nuclide.

(d) Allowable unit leakage applies to maximum operating pressure *Pd* as defined in para. 4.6.3.

FIG. B-1 ALLOWABLE UNIT LEAKAGE FROM DUCT OR HOUSING TO OCCUPIED SPACE

Eqs. (B1) and (B2) conservatively assume no reduction in C_r due to exfiltration of air from room at the duct leakage rate. Room volume is:

$$Vr = Hlw \qquad \text{(B3)}$$

For a rectangular duct, the surface area is:

$$A = \frac{ld}{6}(h + b) \qquad \text{(B4)}$$

where h and b are in inches.
Substituting Eqs. (B1), (B3), and (B4) into Eq. (B2) and transposing, the general equation for a rectangular duct is:

$$L = \frac{Hlw}{10\, ld\, (h + b)} \left(\frac{C_r}{C_d}\right)\left(\frac{0.693}{T^{1/2}} + \overline{AC}\right) \qquad \text{(B5)}$$

If we assume that the duct cross section is square ($b = h$) and that the room is square ($w = l$), Eq. (B5) reduces to:

$$L = \frac{1}{20}\left(\frac{C_r}{C_d}\right) \frac{Hl^2}{hld} \left(\frac{0.693}{T^{1/2}} + \overline{AC}\right) \qquad \text{(B6)}$$

If we further assume that the room height is 20 ft:

$$L = \left(\frac{C_r}{C_d}\right) \frac{l^2}{hld} \left(\frac{0.693}{T^{1/2}} + \overline{AC}\right) \qquad \text{(B7)}$$

If the contaminating nuclide is I-131 ($T^{1/2} = 193.6$ hr) and l = 25 ft and ld = 25 ft,

$$L = \left(\frac{C_r}{C_d}\right) \frac{25}{h} \left(0.00358 + \overline{AC}\right) \qquad \text{(B8)}$$

For a sealed room, $\overline{AC} = 0$

$$L = \frac{1}{11.17}\left(\frac{C_r}{C_d}\right)\frac{1}{h} \qquad \text{(B9)}$$

For a room with $\overline{AC} = 1$:

$$L = \left(\frac{C_r}{C_d}\right)\frac{25.09}{h} \qquad \text{(B10)}$$

For a round duct, Eq. (B4) is replaced by:

$$A = \pi \left(\frac{D}{12}\right) ld \qquad \text{(B11)}$$

and general Eq. (B5) becomes:

$$L = \frac{1}{15.7}\left(\frac{C_r}{C_d}\right) \frac{Hlw}{ldD} \left(\frac{0.693}{T^{1/2}} + \overline{AC}\right) \qquad \text{(B12)}$$

Where N nuclides are present in the duct, it can be shown that:

$$L = \frac{Hlw}{10\, ld\, (h + b)} \frac{\sum_{n=1}^{N} Crn/\text{MP}\cdots}{\sum_{n=1}^{N} \frac{Cdn/\text{M}\cdots}{0.693/T^{1/2}\cdots\overline{AC}}} \qquad \text{(B13)}$$

where
MPC = maximum permissible conce[illegible] μCi/cc

In most nuclide groupings, the term [illegible] $T^{1/2}$ is neglible when compared to even min[illegible]ation air change rates used in practice.
Hence, Eq. (B13) simplifies to:

$$L = \frac{hlw\,\overline{AC}}{10\, ld\, (h + b)} \frac{\sum (Crn \cdots}{\sum (Cdn \cdots} \qquad \text{(B14)}$$

Since $\sum_{n=1}^{N} Crn/\text{MPC}n$

is by 10 CFR 20, the equivalent concentration in MPCs, it can be seen that for a ventilated room Eq. (B14) and Eq. (B5) are essentially the same. It can be concluded that Eq. (B5) is applicable to multinuclide duct leakage as well. Finally, the ratio

$$\sum_{n=1}^{N} (Crn/\text{MPC}n)$$

represents the fraction of maximum permissible dose for the stated period of exposure — usually a 40 hr week.

Determine leak test requirements from para. 5.10.8. If testing is required, determine test method from ASME N510 and required test pressure. Adjust allowable leak rate for test pressure in accordance with para. 4.12.

(b) For spaces required to be maintained at a negative pressure with respect to surrounding areas, the effect of inleakage into negative pressure ducts, outside of the space served, must be evaluated to determine the reduction in air exchange rate and corresponding increase in room MPC. The procedure is as follows.

(1) Determine source terms and parameters for event (e.g., pump seal leak rate, concentration of leakage fluid, space volume, required MPC).

(2) Determine minimum air exchange rate (airflow rate/room volume) required to maintain minimum MPC based on ALARA program.

(3) Determine minimum flow rate to maintain space at design negative pressure.

(4) Determine space design flow rate (this may be selected to ventilate space and maintain environmental conditions).

(5) Determine minimum tolerance [para. (4) above − para. (2) above or para. (4) above − para. (3)].

(6) Determine surface area of duct under negative pressure outside space served.

(7) Divide para. (5) above by para. (6) above at allowable unit leak rate (cfm/ft^2) at maximum operating pressure.

(8) Determine leak test requirements from para. 5.10.8. If testing is required, determine test method from ASME N510 and required test pressure. Adjust leak rate for test pressure in accordance with para. 4.14.

(9) This procedure may not be required if the system is designed, tested, and adjusted such that the minimum design flow from the space served can be achieved and the fan sized to handle the minimum flow plus the infiltration.

(c) Sample Problems

(1) Given: a 30 in. × 12 in. × 50-ft-long duct section at the fan discharge represented by Scheme No. 7 of Fig. B5 has a rated flow of 10,000 cfm. The total surface area of the duct system is 1,050 ft^2. This duct section is under 4 in. w.g. positive pressure and passes through an occupied area 25 ft × 25 ft × 20 ft high where the C_r shall not exceed .32 MPC. The discharge for this ductwork is credited with high-level release. The air change rate in the surrounding room is at least 1 air change.

Determine allowable leakage based on health physics requirements.

Solution: If this same duct is exhausting a contaminated space with an effective radioactivity concentration of 1000 MPCs, it is assumed to have a concentration, C_d, of 100 MPC after passing through the filters. If the occupied space around the duct is to be limited to 0.32 MPC, $C_r/C_d = 0.32/100 = 0.0032$.

Solving Eq. (B1) of B.2.1(d)

$$L = \frac{(H)(1)(W)}{(10)1_d(h+b)} \left(\frac{C_r}{C_d}\right)\left(\frac{0.693}{T^{1/2}} + AC\right) \quad \text{(B15)}$$

where $T^{1/2} = 193.6$ hr

$$L = \frac{20 \times 25 \times 25}{10(50)\,(30+12)}\,(0.0032)\left(\frac{0.693}{T^{1/2}} + 1\right) \quad \text{(B16)}$$

$$L = 0.0019 \text{ cfm/ft}^2 \text{ or } 0.002 \text{ cfm/ft}^2 \quad \text{(B17)}$$

(2) Given: a cubicle containing a normally operating pump with a leak rate of 1 gal/hr at a concentration of 0.15 μCi/cc (see Fig. B-2). Determine:

(a) the required minimum room ventilation rate to maintain ⅓ MPC;

(b) allowable duct inleakage if exhaust fan is rated at 1500 cfm;

(c) unit leakage if duct system consists of 50 ft of 30 in. × 12 in. ductwork outside of cubicle.

Solution: Consider a case with the following parameters:

$$C_F = 0.15\ \mu\text{Ci/cc (I-131)}$$

allowable C_r = ⅓ MPC = ⅓ (9 × 10^{-9} μCi/cc) = 3 × 10^{-9} μCi/cc

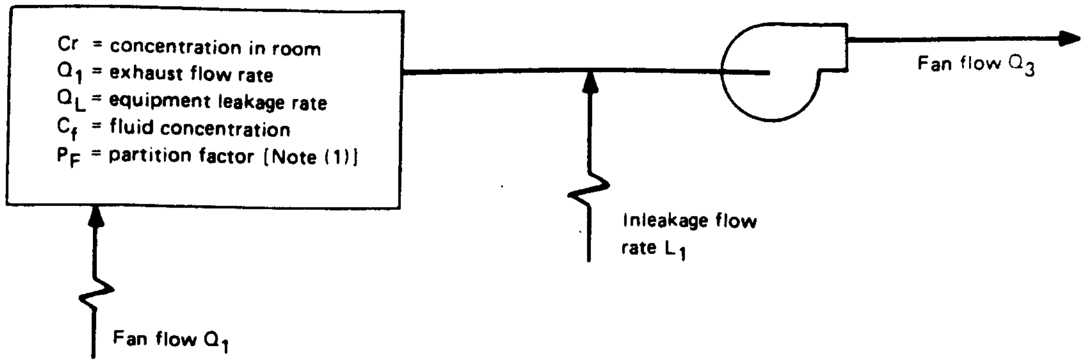
PF = .0075 [reference NUREG-0017 (para. 2.2.5.2), Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from PWRs, April 1976]

$$QL = \frac{\text{gal}}{\text{hr}} = \frac{1\text{ gal}}{\text{hr}} \times \frac{\text{hr}}{60\text{ min}} \times 3785\,\frac{\text{cc}}{\text{gal}} = 63\,\frac{\text{cc}}{\text{min}} \quad \text{(B18)}$$

To meet C_r under the above conditions,

$$Q_1 = QL \times C_F \times PF/C_r \quad \text{(B19)}$$

$$= 63\,\frac{\text{cc}}{\text{min}} \times 0.15\,\frac{\mu\text{Ci}}{\text{cc}} \times .0075/3 \times 10^{-9}\ \mu\text{Ci/cc} \quad \text{(B20)}$$



NOTE:
(1) Partition factor is the fraction of radioactivity in the process fluid that will become airborne when that process fluid leaks into the ambient air

FIG. B-2 SYSTEM PARAMETERS

$$= 2.363 \times 10^7 \frac{\text{cc}}{\text{min}} \times \frac{\text{ft}^3}{30.48\ \text{cm}} = 834\ \text{cfm} \tag{B21}$$

If the fan is sized to handle 1500 cfm for this system, then the allowable clean air inleakage is:

$$1500 - 834 = 666\ \text{cfm} \tag{B22}$$

However, it is also a design criterion to maintain a linear air velocity of 50 ft/min while the 25 ft^2 door is open. (This criterion is set forth to maintain control of airborne radioactivity even though the door is open.) In order to meet this criterion, a flow rate of Q_1 of 50 ft/min. $\times$ 25 ft^2 = 1250 cfm is required. The allowable clean air leakage is then 1500 − 1250 = 250 cfm.

The unit duct leakage is therefore equal to:

$$\frac{250\ \text{cfm}}{\text{(duct length)(duct perimeter)}} = \frac{250\ \text{cfm}}{(50)\ \frac{2(30) + 2(12)}{12}}$$

$$= 0.7 \frac{\text{cfm}}{\text{ft}^2} \tag{B23}$$

B.2.3 Allowable Leakage by Iodine Protection Factor Reduction

(a) General. The Iodine Protection Factor, IPF, is used to quantify the protection offered to plant personnel by nuclear air treatment systems in protected areas of the nuclear facilities design to remain habitable during the following design basis accidents.

The location of the air cooling, ventilation and nuclear air treatment system components, whether inside or outside of the habitability envelope, will affect the value of the IPF. When portions of these systems are located outside the habitability envelope, the effect of duct inleakage or outleakage is a reduction of the IPF value.

(b) Determination of IPF

(1) All System Components Inside Habitability Envelope. The location of all components of the

habitability area air cooling, ventilation and nuclear air treatment systems within the habitability envelope is considered here as the ideal case, from a leakage standpoint, and the basis of evaluating duct leakage.

The IPF is defined as follows:

$$IPF = \frac{\text{dose}^{*}\text{ without protection}}{\text{dose with protection}} \quad (B24)$$

*due to radioactive iodine

The value of the IPF for the configuration shown by Fig. B-3 is determined by the following:

$$IPF = \frac{F_1 + \eta F_2 + F_3}{F_1(1-\eta) + F_3} \quad (B25)$$

$$IPF = \frac{F'_5 + \eta F_2 + F_3}{F'_1(1-\eta) + F_3} \quad (B26)$$

where

$$F'_1 = F_1 + (L_f - L_{o1})\text{ (cfm)} \quad (B27)$$

$$F'_5 = F_5 + (L_{o2} - L_u) - F_3\text{ (cfm)} \quad (B28)$$

$$F_1 = F_5 + (L_{o1} - L_{fl}) + (L_{o2} - L_u) - F_3\text{ (cfm)} \quad (B29)$$

F_1 = makeup airflow rate, cfm
F_2 = recirculation airflow rate, cfm
F_3 = door leakage, cfm
F_5 = control room boundary exfiltration, (cfm)
L_f = duct and housing inleakage with subsequent infiltration, cfm
L_{o1} = outleakage from positive pressure NATS ducts and housings, cfm
L_u = duct and housing inleakage without filtration, cfm
L_{o2} = duct and housing outleakage from positive pressure air conditioning system, cfm

NOTE: $(L_{o1} - L_{fl}) + (L_{o2} - L_u)$ represents the additional makeup air required in order to maintain Control Room Pressurization due to nuclear air treatment system and air conditioning ducts and housings leakage.

(c) Procedure to Determine Allowable Leakage by IPF Value Reduction. The following procedure quantifies the reduction of the effectiveness of the habitability area nuclear air treatment system due to duct leakage, in terms of IPF value reduction. By limiting the percent reduction to IPF value, with respect to duct leakage, the effectiveness of the nuclear air treatment system in limiting personnel dose is maintained.

(1) The determination of the nuclear air treatment system flow rate usually involves an iterative process because it is based on:

(a) the amount of airflow required to maintain a positive pressure differential (approximately 0.125 in. H_2O) across the control boundary, including leakage through the duct system; and

(b) the amount of filtered recirculation air required to achieve the required iodine protection factor (IPF).

(2) The air required to pressurize the control room is first calculated and an assumed quantity for duct leakage added to it. After duct and housing leakage calculations have been performed for the system configuration and layout, the original assumption is revised accordingly. The makeup airflow rate should be equal to the control room exfiltration air plus duct outleakage minus the duct inleakage and control room infiltration (if any).

(3) The filtered recirculation air quantity is determined by calculating the ratio of recirculated air to outside air required to meet a conservative IPF. The conservative IPF is determined by calculating the minimum acceptable IPF required to meet General Design Criterion 19 limits and multiplying this by a safety factor which will allow for a decrease in IPF due to duct leakage. The recirculation air quantity is then rechecked and revised as necessary when evaluating the iodine protection factor reduction due to duct leakage.

(4) After the outside air and recirculated air quantities are initially determined and the equipment located, the ductwork can be sized and routed. The pressure in the duct relative to the surrounding area must also be determined for the purpose of duct leakage calculations.

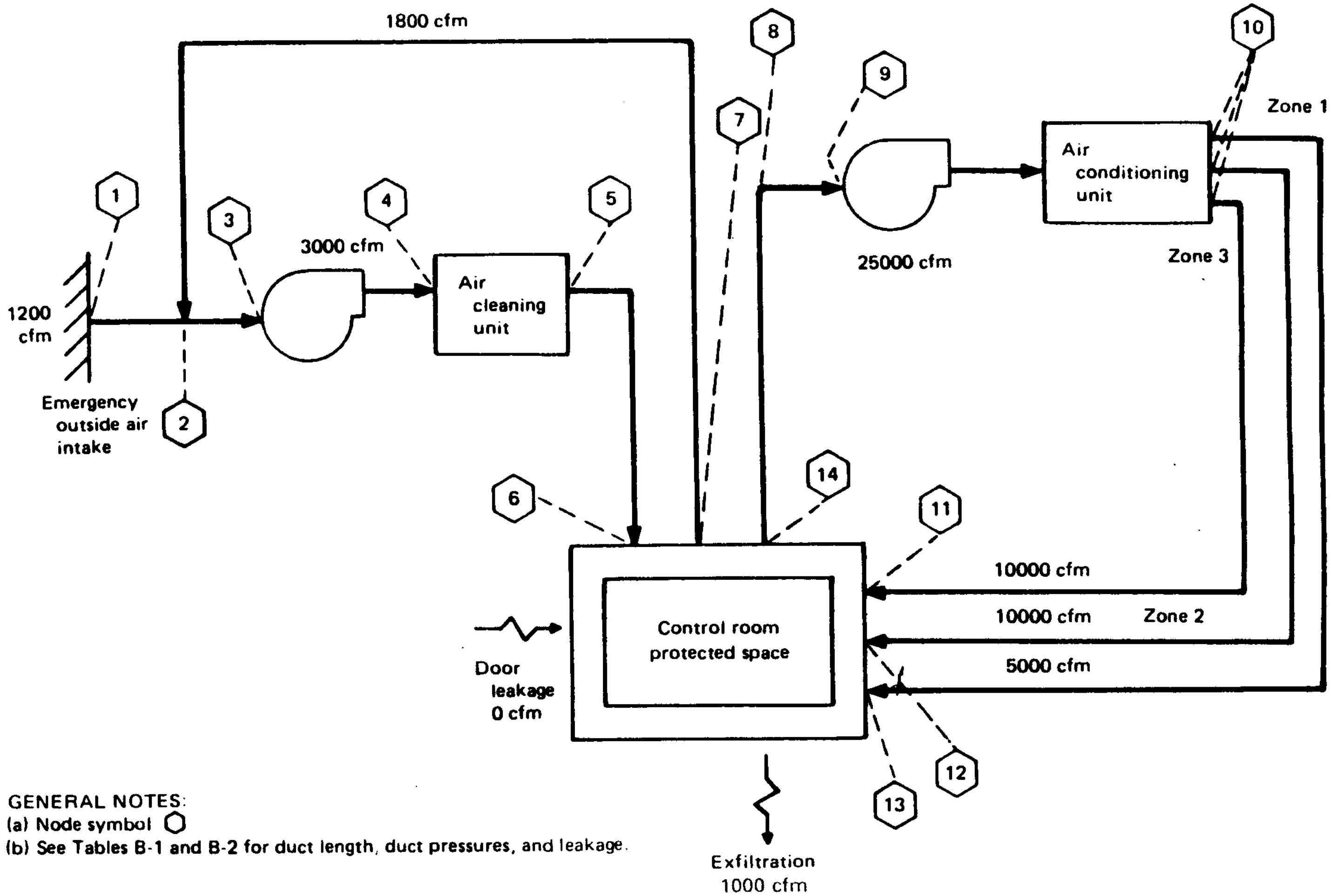
(5) Next, calculate duct surface areas outside of habitable zone, classify as positive pressure, filtered recirculation, unfiltered recirculation.

(6) Based on a parametric analysis, using the Eqs. (B25) through (B29), determine the maximum allowable leak rates for L_f, L_{o1}, L_{o2}, L_u such that the IPF is achieved.

(7) Determine unit leak rate by dividing allowable leak rates in para. (c)(6) above by surface areas in para. (c)(4) above. This is the unit leak rate at operating pressure.

(8) Determine leak test method to be used from ASME N510 and determine test pressure.

(9) Adjust allowable leak rate for test pressure in accordance with para. 4.14.



GENERAL NOTES:
(a) Node symbol ⬡
(b) See Tables B-1 and B-2 for duct length, duct pressures, and leakage.

(d) Sample Problems

(1) Given: A control room complex is provided with a safety-related nuclear treatment system and a cooling system. Figure B-4 shows the configuration of the system. During accident conditions, the nuclear air treatment system is required to provide a minimum IPF value of 200.

The air-cleaning unit and the air cooling unit are located outside of the protected area (i.e., the habitability envelope) in a contaminated interspace. System parameters are given in Table B-1 and Table B-2.

Determine: Allowable leakage for L_{f1}, L_{o1}, L_{o2}, L_u to meet or exceed the minimum IPF.

Ductwork and Housing Leakage Classifications: From Fig. B-7, Scheme No. 19, the leakage classes for the recirculation air-cleaning unit are determined as Class II. Note, since the makeup air is not filtered prior to entering the return duct, the return duct is assigned leakage Class I.

The leakage classes of the air-conditioning unit are Leak Class I for the negative pressure return air duct, because any inleakage would be unfiltered, and Leak Class II for the positive pressure supply duct (assuming control room boundary pressure requirements can be maintained).

Solution: For this example, a nuclear air treatment system of 3000 cfm flow capacity has been selected based on 1200 cfm required for pressurization and a ratio of recirculation airflow to outside air flow of 1.5. This ratio has been selected in order to obtain an initial conservative IPF of 248. For this hypothetical case, a minimum acceptable IPF of 200 will be assumed. In addition to the nuclear air treatment system, the control room also requires a recirculating type air-conditioning system with an assumed capacity of 25,000 cfm (approximately 100 tons of cooling capacity). The exfiltration has been determined to be 1000 cfm maximum at 0.125 in. w.g. (Refer to Fig. B-3.)

The maximum allowable duct leakage that will satisfy the health physics requirements is determined for this example by evaluating the reduction in the iodine protection factor (IPF). The iodine protection factor is used to express the reduction in radioiodine concentration within the control room as a result of filtration and recirculation.

For this example, the IPF is determined assuming an unfiltered inleakage (through the control room boundary) of zero since all doors have airlock vestibules and a filter efficiency of 99%. Using Eq. (B12) gives:

$$\mathrm{IPF} = \frac{1200 + (0.99)\,(1800) + 0}{(1-0.99)\,1200 + 0} = 248.5 \qquad \text{(B30)}$$

For this particular example, a minimum IPF of 200 is required in order to meet the dose requirements of General Design Criterion 19.

In this case, as long as there is no duct leakage, the minimum required IPF is exceeded. However, the IPF is reduced when the duct inleakage and outleakage are accounted for. This must, therefore, be evaluated to determine if the reduced IPF is still acceptable.

The surface area for the air cleaning duct and housing under a negative pressure which would experience infiltration with subsequent filtration L_f is:

Nodes	Surface Area
1-2	131
2-3	84
7-2	236
	451 ft^2

The surface area of the nuclear air treatment system under a positive pressure is:

Nodes	Surface Area
3-4	28
4-5	842
5-6	283
	1153 ft^2

For the air-conditioning systems, the corresponding negative pressure area is:

Nodes	Surface Area
14-8	750
8-9	375
	1125 ft^2

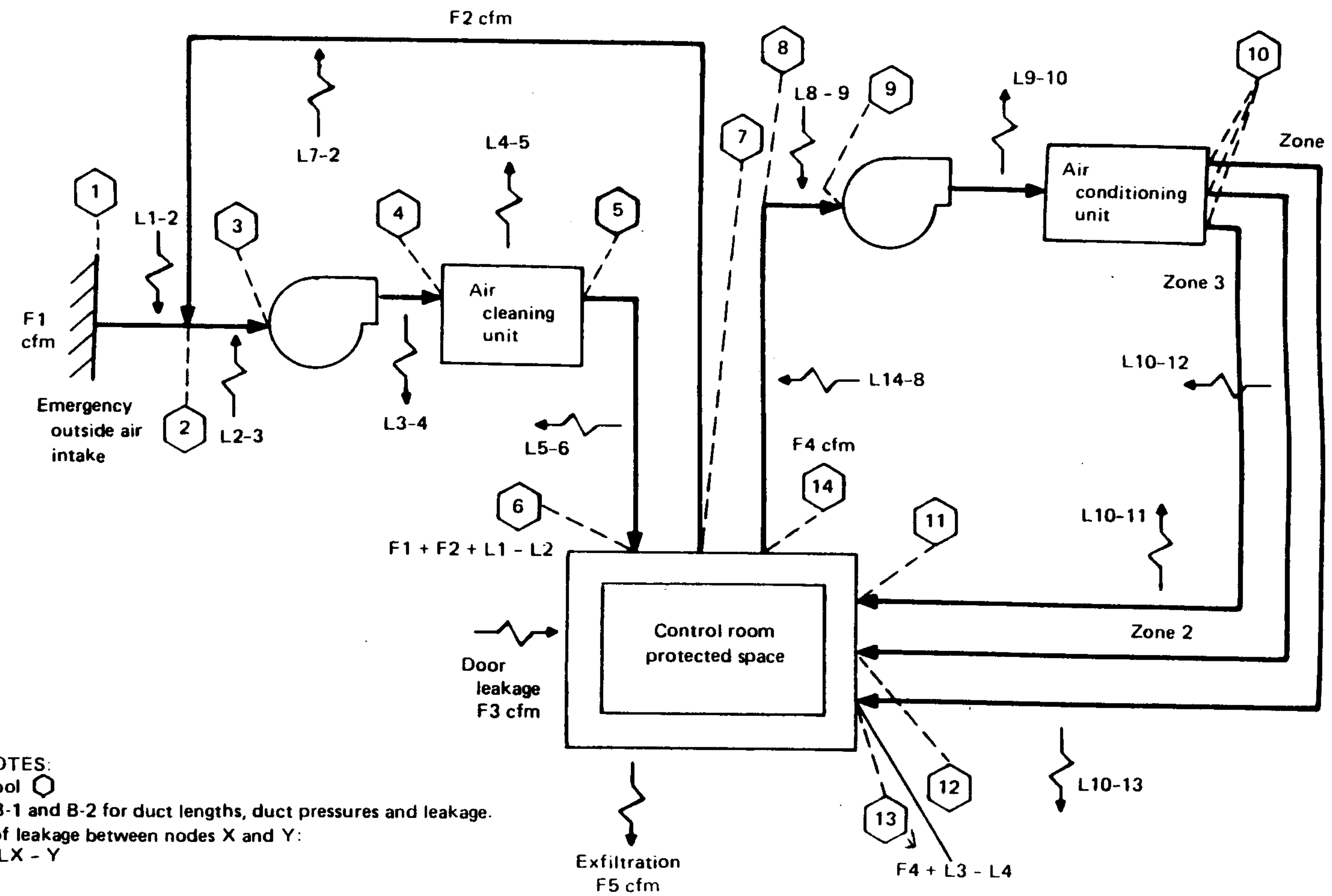
and under a positive pressure:

Nodes	Surface Area
9-10	376
10-11	400
10-12	400
10-13	250
	1426 ft^2

For the nuclear air treatment system we will assume, based on prior test experience and the type of duct construction used, that the air-cleaning unit leak rate, in the operating pressure range specified, will be 0.025 cfm/ft^2. This results in:

$$L_f = 451 \text{ ft}^2 \times 0.025 \text{ cfm/ft}^2 = 11.3 \text{ cfm} \qquad \text{(B31)}$$

$$L_{o1} = 1153 \text{ ft}^2 \times 0.025 \text{ cfm/ft}^2 = 28.8 \text{ cfm} \qquad \text{(B32)}$$



GENERAL NOTES:
(a) Node symbol ⬡
(b) See Table B-1 and B-2 for duct lengths, duct pressures and leakage.
(c) Direction of leakage between nodes X and Y:
—⁄\/→ LX - Y

FIG. B 4 CONTROL R[illegible] [illegible] LEAKAGE PATHS

TABLE B-1 CONTROL ROOM NUCLEAR AIR TREATMENT SYSTEM PARAMETERS FOR LEAKAGE ANALYSIS

Nodes From–To	Duct Size	Duct Length, ft	Duct Surface Area, ft^2	Duct Pressure, in. w.g.	Leakage Class
1-2	10 in.	50	131	−1.0	II
2-3	16 in.	20	84	−2.0	II
3-4	22 in. × 12 in.	5	28	+10.0	I
4-5	3 ft 0 in. × 7 ft 0 in. [Note (1)]	40	842	+10.0	I
5-6	22 in. × 12 in.	50	283	2.0	II
7-2	12 in.	75	236	1.0	I

NOTE:
(1) Housing dimensions.

TABLE B-2 CONTROL ROOM AIR CONDITIONING SYSTEM PARAMETERS FOR LEAKAGE ANALYSIS

Nodes From–To	Duct Size	Duct Length, ft	Duct Area, ft^2	Duct Pressure, in. w.g.	Leakage Class
14-8	60 in. × 30 in.	50	750	−2.0	I
8-9	60 in. × 30 in.	25	375	−3.0	I
9-10	6 ft. 0 in. × 8 ft. 0 in. H [Note (1)]	10	376	+5.0	I
10-11	40 in. × 20 in.	40	400	+4.0	II
10-12	40 in. × 20 in.	40	400	+4.0	II
10-13	26 in. × 12 in.	40	250	+4.0	II

NOTE:
(1) Housing dimensions.

Nuclear air treatment system net leakage = $(L_{o1} - L_f)$ = +17.5 exfiltration.

For air-conditioning systems, assume the leak rate to be 0.07 cfm/ft²:

$$L_u = 1125 \text{ ft}^2 \times 0.07 \text{ cfm/ft}^2 = 78.8 \text{ cfm} \quad \text{(B33)}$$

$$L_{o2} = 1426 \text{ ft}^2 \times 0.07 \text{ cfm/ft}^2 = 99.8 \text{ cfm} \quad \text{(B34)}$$

Net air-conditioning system leakage = $(L_{o2} - L_u)$ = +21 cfm exfiltration. Furthermore, with airlock vestibules $F_3 = 0$.

Inserting into Eqs. (B27) and (B28) gives:

$$F'_1 = F_1 + (L_f - L_{o1}) \quad \text{(B35)}$$

$$F'_1 = 1200 + (11.3 = 28.8) = 1182.5 \quad \text{(B36)}$$

$$F'_5 = F_5 + (L_{o2} - L_u) - F_3 \quad \text{(B37)}$$

$$F'_5 = 1000 + (99.8 - 78.8) - 0 = 1021 \quad \text{(B38)}$$

Using Eq. (B26):

$$\text{IPF} = \frac{1021 + (0.99)(1800) + 0}{(1182.5)(1 - 0.99) + 0} \quad \text{(B39)}$$

$$= 237$$

Since IPF is greater than the required IPF with margin, the duct leakage is acceptable.

Based on this analysis, the actual leakage from each duct segment and housing should be calculated based on actual operating pressure to determine actual allowable leakage. This value should then be corrected for test pressures to establish acceptance criteria for duct/housing leak testing.

Subsequently, if actual test results indicated that the inleakage was:

L_f = 50 cfm
L_{o1} = 30 cfm
L_u = 200 cfm
L_{o2} = 50 cfm

the IPF would be determined:

$$F'_1 = 1200 + (50 - 30) = 1220 \quad \text{(B40)}$$

$$F'_5 = 1000 + (50 - 200) = 850 \quad \text{(B41)}$$

$$\text{IPF} = \frac{850 + 0.99\,(1800)}{(1220)\,(.01)} = 215.7 \quad \text{(B42)}$$

which is still above the minimum IPF and still provides a margin.

B3 ADDITIONAL LEAKAGE CRITERIA

Additional leakage criteria may be developed by the owner or system designer to meet plant specific ALARA criteria at the owner's option. Additional criteria may take the form of specifying nuclear air treatment system effectiveness or system quality parameters. It is recommended that the bases for these additional criteria be documented to allow future evaluation of test data. Examples of criteria which could be established are as follows.

B3.1 Nuclear Air Treatment System Effectiveness

One approach to establishing values [illegible]able leakage rates based on nuclear air trea[illegible]stem effectiveness is to provide arbitrary valu[illegible]cent of nuclear air treatment system flow ra[illegible]ed on leakage classification (refer to para. B.[illegible]

The values that have been historica[illegible] are shown in Table B-3. However, these ra[illegible]not be representative of actual system design [illegible]ince system design flow rates may be established due to non-air-cleaning requirements. For these cases, the procedure for establishing air-cleaning [illegible]akage rates should follow the format used in para. B.2.1(a)(2). Determine minimum requirements, establish flow rate tolerance and proportion across duct surface area.

B3.2 System Quality

There may be a desire to establish benchmark leakage rates for various leakage classes and/or types of construction in order to determine quality during the installation process.

The owner or system designer should establish the leak rate associated with the type of construction by previous test experience, calculation, or by a shop or field test at the beginning of the installation.

The owner or his designee shall randomly select sections of ducts or individual housings to leak test *in situ*. Selection of duct sections may be chosen based

TABLE B-3 MAXIMUM ALLOWABLE LEAKAGE[1] FOR AIR CLEANING EFFECTIVENESS (PERCENT OF RATED FLOW)

Leakage Class [Note (2)]	ESF			Non-ESF		
	Duct [Note (3)]	Housing	Total [Note (4)]	Duct [Note (3)]	Housing	Total [Note (4)]
I	0.10	0.10	. . .	0.50	0.10	0.6
II	1.00	0.20	1.2	5.00	1.00	6.0

NOTES:

(1) Leak rate at operating pressure

(2) Refer to Section B4 for configuration that determines leakage class. Leakage is apportioned to surface area by

$$L_S = \frac{a}{A} \times \frac{P \times Q}{100}$$

where

L_S = allowable leakage in duct section, scfm

P = allowable percent leakage

Q = system rated flow, cfm

a = surface area of the duct section, ft^2

A = surface area of the total system ductwork per leakage class, ft^2

$\frac{L_S}{a}$ = the allowable unit leakage by this criteria, cfm/ft^2

(3) All ducts under positive pressure which discharge into the plant stack for high level release credit shall be leakage Class I.

(4) Assumes housing surface area is 20% of duct surface area. Duct and housing leakages shall be adjusted for actual housing and duct surface area ratios, but the total percent leakage shall not exceed the sum of the listed percent leakages for duct and housing.

on ANSI/ASQC Z1.4 or other equivalent standard; however, this is not mandatory.

B4 NUCLEAR AIR TREATMENT SYSTEM CONFIGURATIONS AND LEAKAGE CLASSES

A nuclear air treatment system can be defined schematically in terms of three spaces and two components.

The three spaces (refer to para. 3 definitions) may be either exterior or interior and are:

(a) the contaminated space

(b) the protected space

(c) the interspace

(1) contaminated

(2) clean

The two components are:

(d) fan

(e) air-cleaning unit

All three of the above spaces represent possible locations for the different parts of the nuclear air treatment system. The contaminated and protected spaces also include the points of system origin and termination, respectively. The interspace refers to all other spaces — contaminated or clean — where the nuclear air treatment system or its parts may be located.

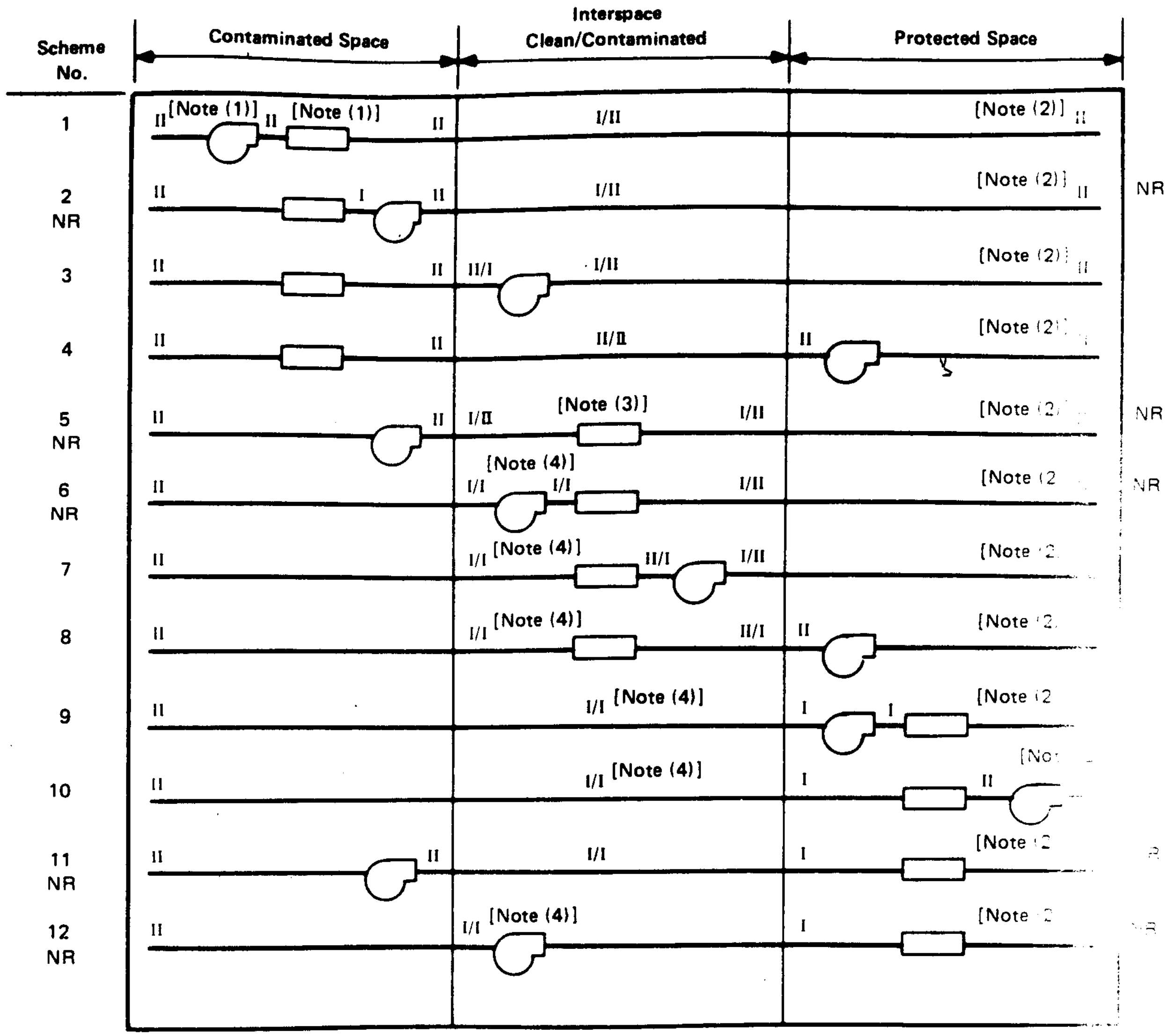
Examples of contaminated space/interspace/protected space arrangements are:

Contaminated Space	Interspace	Protected Space
Containment	Plant spaces	Offsite
Plant site	Equipment room	Control room
Secondary containment	Equipment room	Offsite

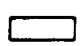
For recirculating systems, the contaminated space and protected space merge into one "contaminated and protected space."

Leakage Classes I and II have been assigned to the various sections of each nuclear air treatment system to represent the qualitative effect of leakage on the nuclear air treatment system function. Thus, Leakage Class II classification indicates that due to system configurations and location a higher leak rate may be allowable. Conversely, a Leak Class I classification indicates a more stringent leak rate is required.

Leakage Classes are noted on Figs. B-5, B-6, and B-7.



NOTES:

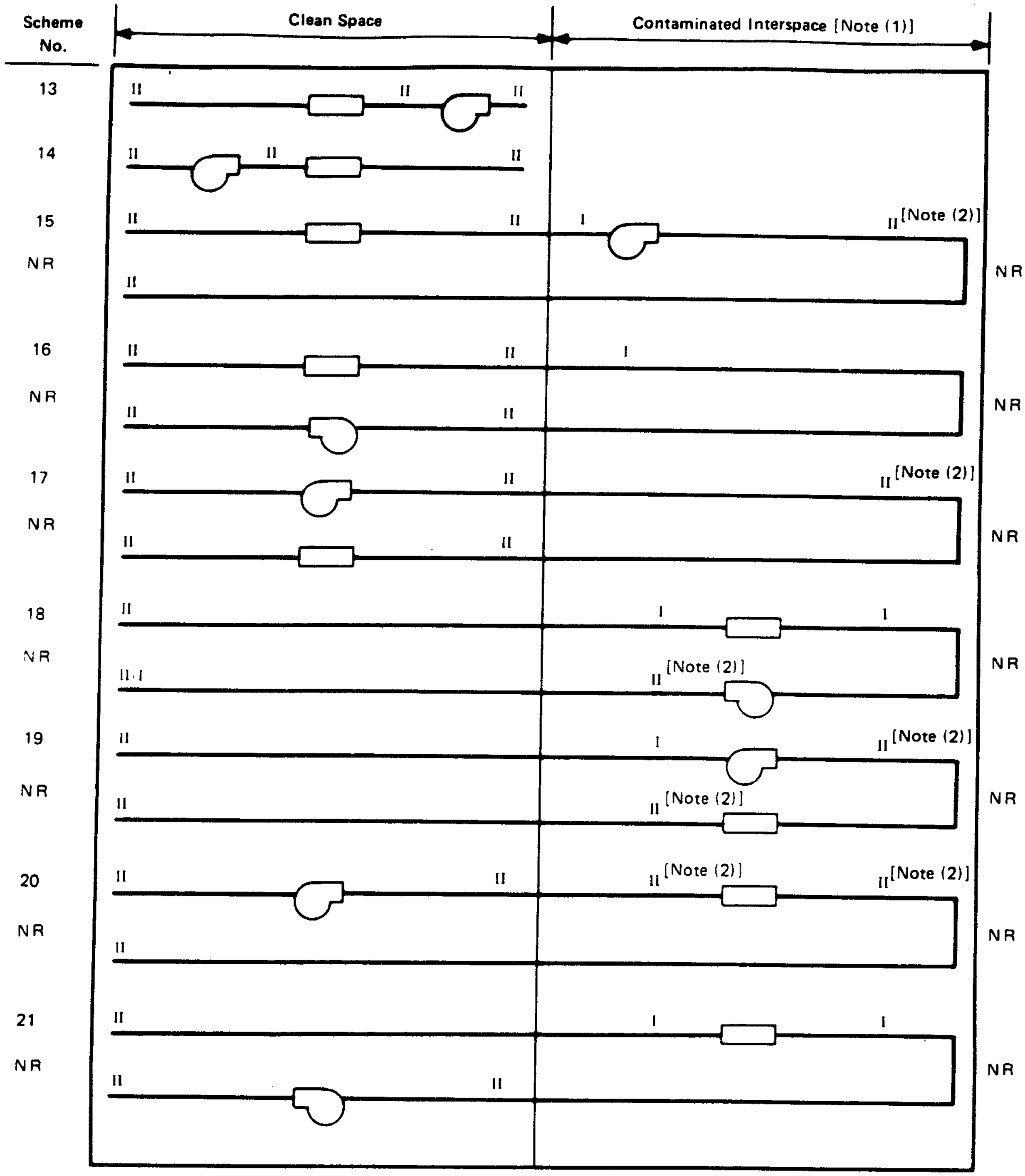
(1) Symbols —  Air Cleaning Unit  Fan
NR — Not Recommended

(2) All ducts under positive pressure which discharge into the plant stack for high level release credit shall be leakage Class I.

(3) Space classification is based on the relative concentration of the space with respect to the duct (e.g., *Contaminated Interspace* means concentration within space is greater than duct or housing at that point). Thus, as duct concentration changes due to filtration, the space classification will change in a given area.

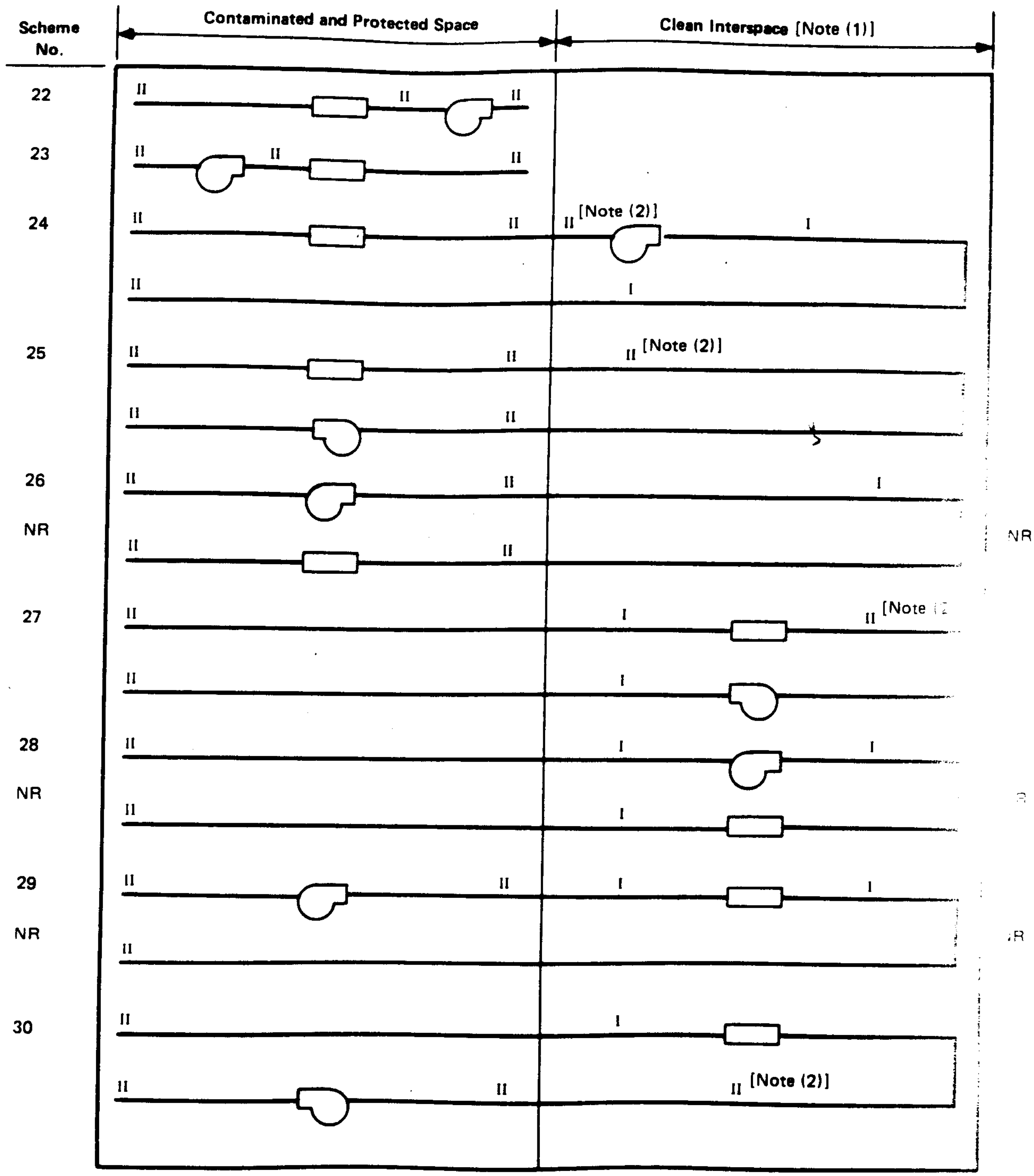
(4) Noted duct section which pass through a Clean Interspace and which are under a negative pressure for all modes of operation may be leakage Class II.

FIG. B-5 SINGLE PASS AIR CLEANING SYSTEM CONFIGURATIONS



NOTES.
(1) Contamination level of Fluid within ductwork < contamination level of interspace.
(2) Leak Class I shall be used if ductwork is under negative pressure with respect to interspace during normal or transient system operation.

FIG. B-6 RECIRCULATING AIR CLEANING SYSTEM CONFIGURATIONS — I



NOTES.
(1) Contamination level of Fluid within ductwork > > contamination level of interspace.
(2) Leakage Class I shall be used if ductwork is under positive pressure with respect to interspace during normal or transient system operation.

FIG. B-7 RECIRCULATING AIR CLEANING SYSTEM CONFIGURATIONS — II

NONMANDATORY APPENDIX C
Manifold Design Guidelines

(This Appendix is not part of ASME N509-1989, and is included for information purposes only.)

C1 GENERAL

C1.1 Test manifolds discussed in this Appendix are those required for test agent injection and sampling to perform in-place aerosol tests per ASME N510-1989.

C2 MANIFOLD REQUIREMENTS FOR IN-PLACE TESTS

C2.1 Housing and frame leak tests usually do not require specific provision for testing; only simple threaded penetrations are needed.

C2.2 Determination of airflow rate and velocity distribution may require access ports for traverse measurements of airflow velocity on systems too small or too contaminated for entry of a person to take the necessary data. Specifically, there must be provision to measure the airflow rate which is best measured in a straight duct run on the basis of standard pitot tube traverse. If these conditions do not exist where the velocity is greater than 600 fpm, then the measurements should be taken downstream of a HEPA filter bank. This is the same location the airflow distribution test data is usually taken.

The ports shall provide sufficient access to allow at least 10 measurements to be taken evenly over the face of the HEPA filter bank. Systems with more than 10 filters will be large enough to allow entry unless unusual contamination restricts entry.

C2.3 Challenge/air mixing uniformity testing requires access similar to that required for airflow distribution. The difference is that the measurements must be taken upstream of the HEPA or adsorbent bank. Large systems usually allow entry for personnel to locate the sample lines by hand, but small or unusually contaminated systems must be tested using a remotely controlled traverse.

C2.4 The most common situation that requires initial preparation for manifold design is leak testing component banks in series. There are many possible configurations that create this situation and the most common is the series placement of components in a filter housing. HEPA-Carbon is the most common arrangement but, HEPA-HEPA, Carbon-Carbon, HEPA-Carbon-Carbon arrangements and may require the use of manifolds. Refer to Fig.

C2.5 Manifolds may be necessary in a system without components in series. An example where injection manifold is required to obtain uniform test agent distribution is a recirculation system with no inlet duct before the filter bank.

C2.6 Manifolds are required whenever injection of a test agent at a single point does not result in the required distribution of the agent over the inlet face of the filter bank required for the performance of a leak test or where sampling is required from an unmixed stream.

C3 ADDITIONAL REASONS FOR USE OF PERMANENTLY INSTALLED MANIFOLDS

C3.1 Permanently installed manifolds, which have passed ASME N510 acceptance testing, provide a quick and simple means to repeat leak tests.

C3.2 Alternate methods of testing when a single point sample cannot be used, including temporary manifolds, are more time consuming than using a permanently installed manifold system.

C3.3 Other methods require entering the air-cleaning unit to install a temporary manifold, take multiple samples, place a shroud, remove a component, etc. This not only takes time, but can be a personnel exposure and contamination control problem with a contaminated system.

C3.4 A permanently installed manifold system allows a bank leak test of the air-cleaning unit without turning the air-cleaning unit off or breaching the pressure boundary that could affect system operation.

C3.5 Properly designed temporary manifolds can be installed in a few minutes except for very large systems (where the time frame for any alternate procedure is equally extended). Once installed, and the access door closed, the time constraints for ALARA or system nonavailability is usually reduced.

C3.6 Properly designed and tested permanently or temporarily installed manifolds provide a more technically defensible test result than alternate methods.

C3.7 Manifolds, in general, require less training and technical depth for use than alternate methods.

C4 INJECTION MANIFOLDS

C4.1 An injection manifold is a device which is used to produce a uniform distribution of the injected test agent over the cross section of a housing to permit proper leak testing of a filter bank. The test agent must be uniform, within ±20% of the average, across the face of the bank including frame-to-housing interface and confirmed by the air-aerosol mixing uniformity Test per Section 9 of ASME N510.

C4.2 The complexity in design and execution of an injection manifold varies greatly depending on the air-cleaning unit configuration. An injection manifold downstream of a Type III adsorber is relatively simple because the sample manifold will follow the adsorber slots and take advantage of the high velocity flow exiting the slots. Refer to Fig. C-2, Sheets 1-2.

On the other extreme, a HEPA-HEPA configuration may be very difficult because the air filter bank is at low velocity and usually laminar exiting the first HEPA. The distance between component banks affects the design significantly.

C4.3 DOP injection manifolds require larger diameter and additional design consideration than for R-11 manifolds. R-11 is a normally gas at ambient conditions so condensation and plateout is *usually* not a problem. As DOP aerosol is subject to plateout, condensation and agglomeration; the following recommendations are more critical. The design of DOP manifolds is based on experience.

C4.4 General Rules Appliable to All Injection Manifolds

C4.4.1 The total area of the exit holes is typically 1.25 times the cross section of the pipe which the holes are located.

C4.4.2 Headers should have a cross section 1.25 times the sum of the cross sections of all the branches. [Four branches each 1 in. (0.8 in^2) results in a header of (1.25)(4)(0.8 in^2) = 3.9 in^2 or 2¼ in. diameter header.]

C4.4.3 Para. C5.4 is subject to allowances for standard drill and pipe dimensions. When compromise must be made it is better to err on the high side of hole or branch area.

C4.4.4 Valves should be used only to isolate branches. If possible it is better to avoid them because valve settings may change and require reverification of manifold design or adjustment.

C4.4.5 The low point of each branch should have a screw cap to allow the leg to be drained if necessary.

C4.4.6 Sharp radius changes of direction should be avoided. Compound bends are preferable to multiple elbows. When elbows are used, they should be kept to the minimum. Two 45 deg. elbows in series are better than one 90 deg. elbow.

C4.4.7 The ID of the manifold should be smooth and free from sharp edges, burrs, crevices.

C4.4.8 Existing high-velocity areas and/or turbulences (if any) within the air-cleaning unit should be used to enhance mixing and therefore simplify the manifold design.

C4.4.9 The inlet to the injection manifold should be at a location accessible for connecting the generator.

C4.4.10 The location of permanent manifolds should be checked for possible interference with component changeout and other maintenance access requirements.

C4.4.11 Manifold outlet holes should be oriented to take advantage of the flow path for mixing. Configurations that would subject the manifold holes to direct velocity pressure from the air flow should be avoided in all but the most exceptional circumstances. Holes should be on a staggered pattern, 90 deg. to each other, 45 deg. on the centerline. Refer to Figs. C-2 and C-3.

C4.5 The design of aerosol injection manifolds is dependent on the bank and housing configuration.

C4.5.1 All injection manifold designs need to be tested to assure meeting the Air/Aerosol Mixing Uniformity requirements of Section 9 of ASME N510.

C4.5.1.1 If adjustments are required in a manifold to pass the uniformity test, they should be permanent. This will eliminate a need to repeat the uniformity test each time a leak test is performed.

C4.5.1.2 Examples of permanent adjustments would be:

(*a*) drilling out holes to a larger diameter,

(*b*) closing (full or partial) holes with solder or weld metal,

(*c*) addition of holes,

(*d*) addition of orifice plates,

(*e*) addition of permanent baffles to manifold,

(*f*) basic change of design.

C5 SAMPLING MANIFOLDS

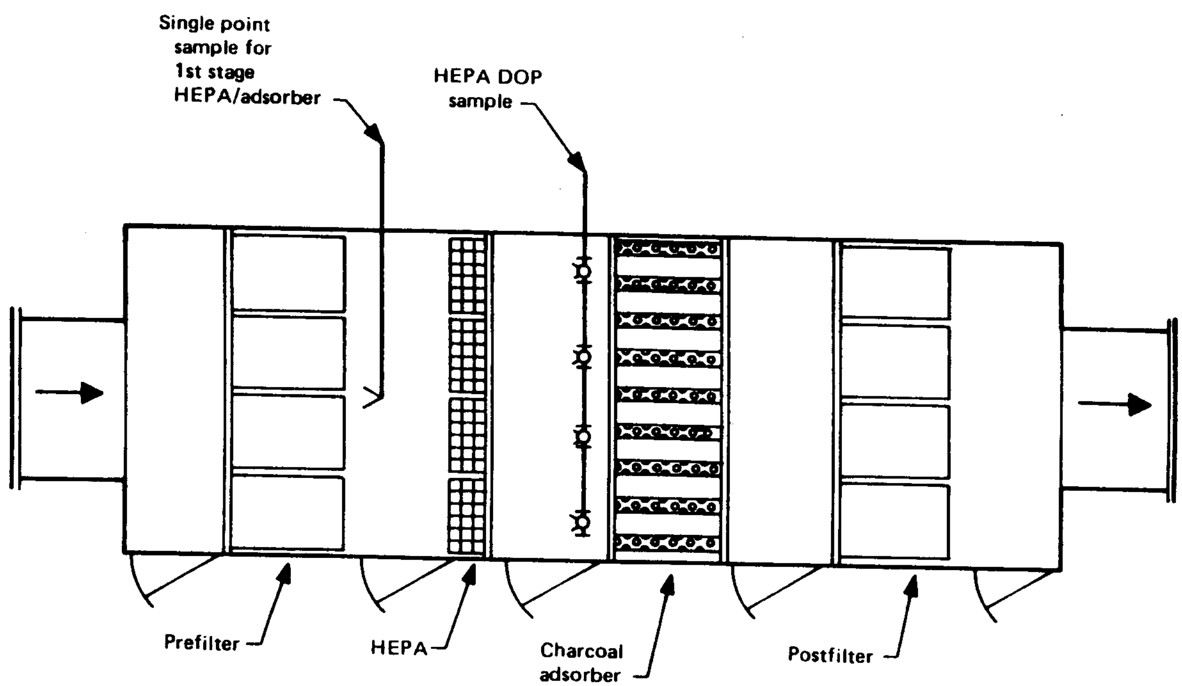
C5.1 In general, all the design points mentioned for injecting manifolds apply to sampling manifolds. The main difference is the low reduced concentration of the challenge agent, on the order of a fraction 1,000 to 100,000 less. This greatly reduces the problem of aerosol agglomeration and plateout. Further, the challenge agent is usually in thermal equilibrium with the airstream and manifold so condensation should not be a problem.

C5.2 A major point to stress is that the aerosol size used for ASME N510 testing contains particle size less than 5 microns; therefore, isokinetic sampling is not required. For gases, such as halide, isokinetic sampling is not required.

C5.3 A larger number of branches is required to ensure detecting a leak point; the diameters are based on airflow considerations.

C5.4 Even with small diameter sampling manifolds, the sampled volume is usually significant as far as the time needed to reach the detector element. Sample pumps in most detectors are sized for standard ¼ in. nylon lines; therefore, an auxiliary pump blower is usually required to avoid delays in the sample from the furthest point reaching the detector. This [illegible] is calculated from the internal volume and [illegible] of the manifold and the capacity of the pump [illegible] delay must be factored into the penetration calc[illegible]s for adsorber beds.

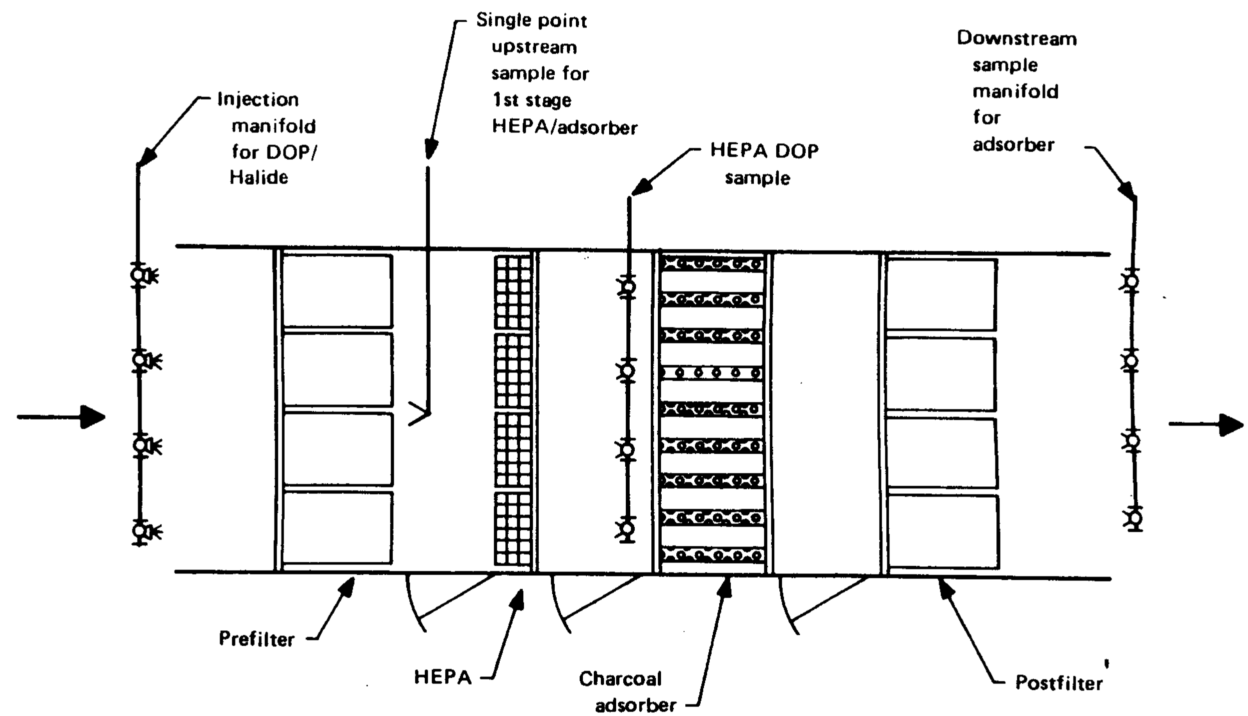
C5.5 As most detectors are designed to [illegible] at or near ambient pressures, care is required [illegible]cting the detector to an auxiliary blower system [illegible] not be "hard piped" to a closed system or [illegible] to the positive output pressure of the blower. [illegible] hole in the main sample line or a "tee" before [illegible]er is preferred. The setup must not allow dilu[illegible] to enter the *detector* sample line (dilution o[illegible]ample past the takeoff point is not relevant). [illegible] al-low velocity pressure from the auxilia[illegible]r to change the pressure in the detector samp[illegible] connection must be firm enough that no change [illegible] occur during the test.



GENERAL NOTES:
(a) Injection of DOP/Halide is in inlet duct.
(b) Downstream DOP/Halide sample port may be located in outlet duct

Plan A – Ducted Inlet/Outlet
HEPA-Carbon Configuration

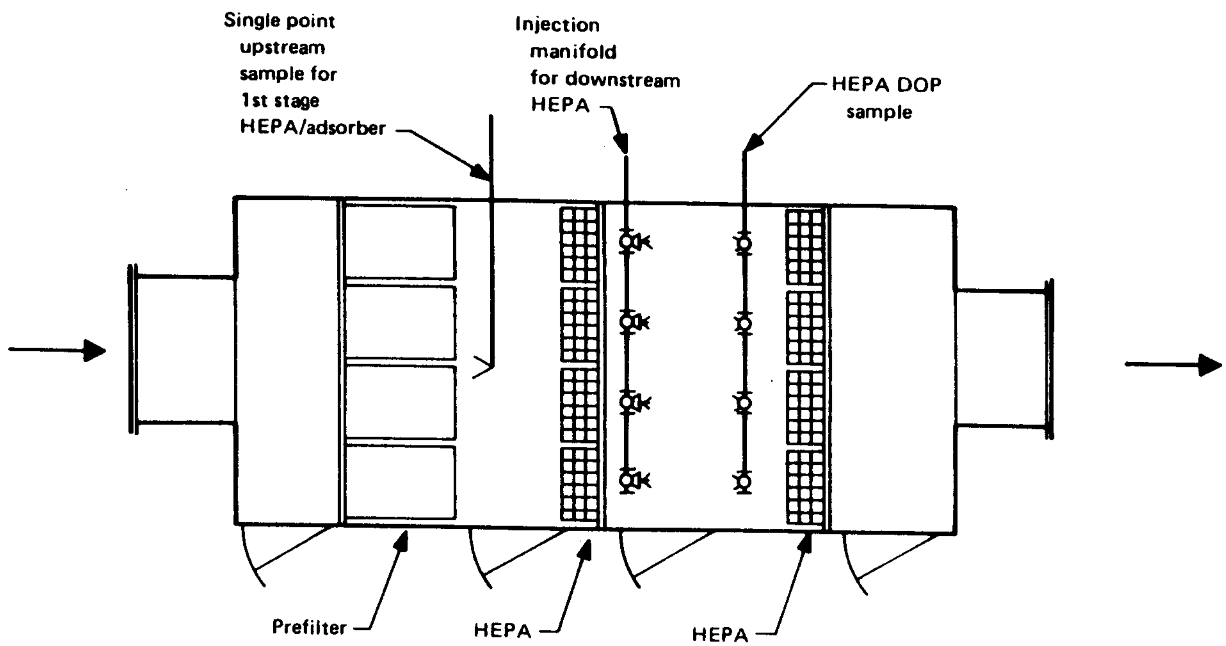
FIG. C-1 COMMON CONFIGURATIONS REQUIRING TEST MANIFOLDS



GENERAL NOTES:
(a) If an inlet duct is provided the DOP/Halide injection can be located in the inlet duct.
(b) If an outlet duct is provided the downstream sample can be located in the outlet duct.

Plan B — Unducted Inlet/Outlet
HEPA-Carbon Configuration

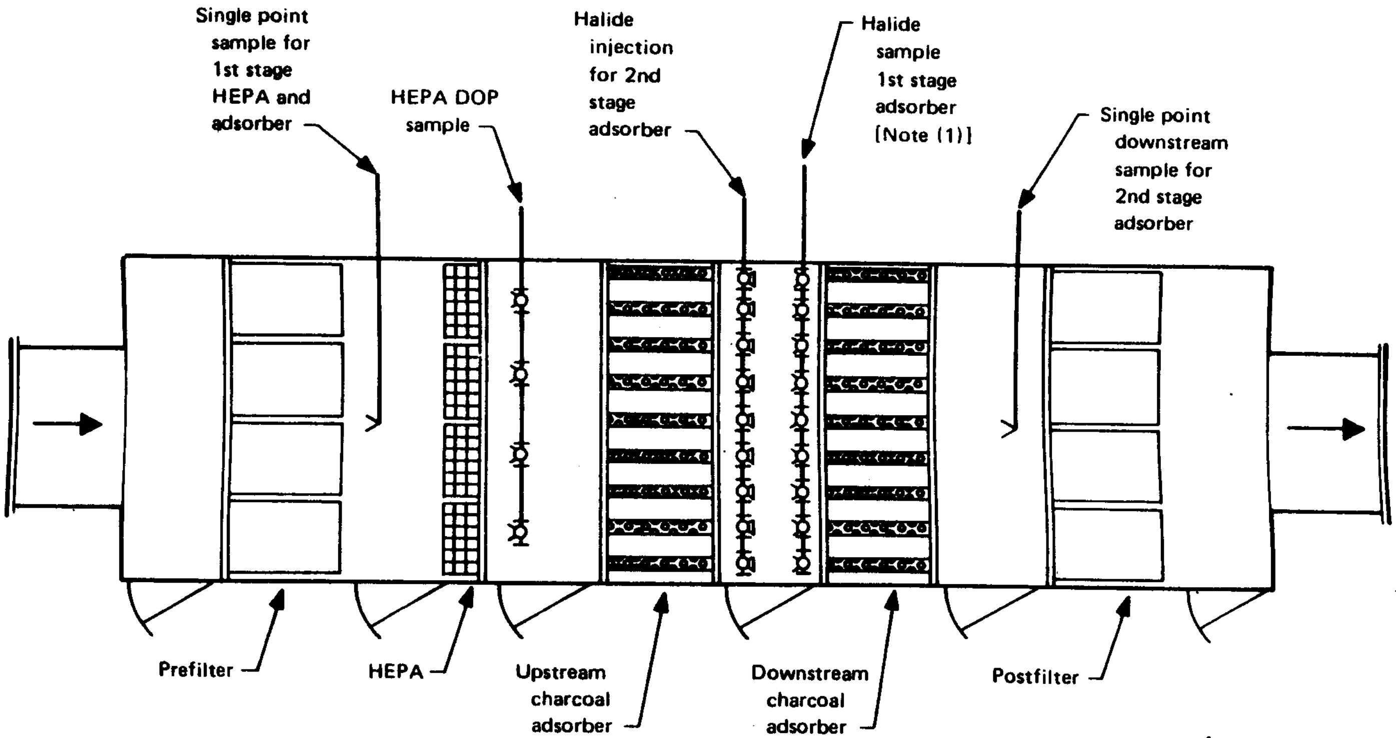
FIG. C-1 COMMON CONFIGURATIONS REQUIRING TEST MANIFOLDS (CONT'D)



GENERAL NOTES:
(a) Injection of DOP/Halide is in inlet duct
(b) Downstream DOP/Halide sample point may be in outlet duct

Plan C — Ducted Inlet/Outlet
HEPA-HEPA Configuration

FIG. C-1 COMMON CONFIGURATIONS REQUIRING TEST MANIFOLDS (CONT'D)

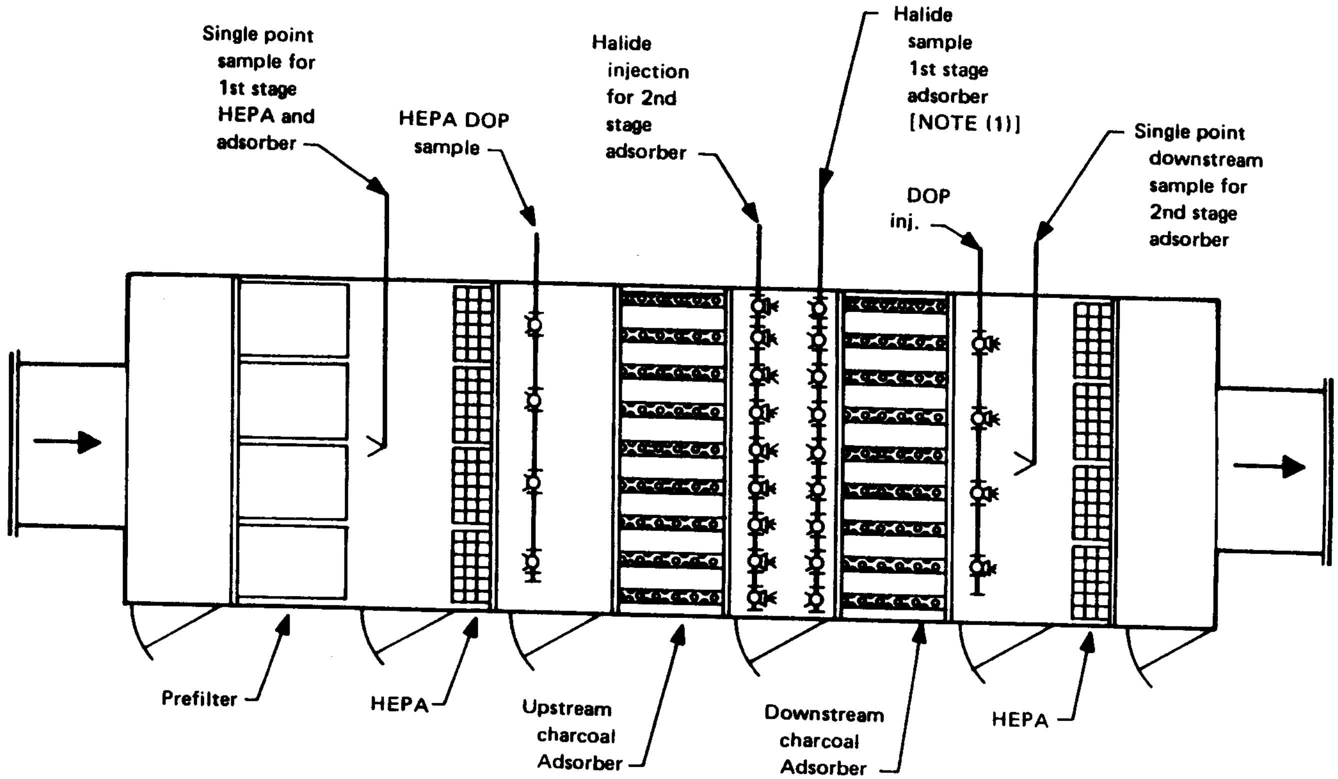


GENERAL NOTES:
(a) Injection of DOP/Halide is in inlet duct
(b) Downstream DOP/Halide sample point may be in outlet duct

NOTE:
(1) 1st stage Halide sample point can be used for 2nd stage upstream sample in lieu of single point sample

Plan D — Ducted Inlet/Outlet
HEPA-Carbon-Carbon Configuration

FIG. C-1 COMMON [illegible] TEST MANIFOLDS (CONT'D)

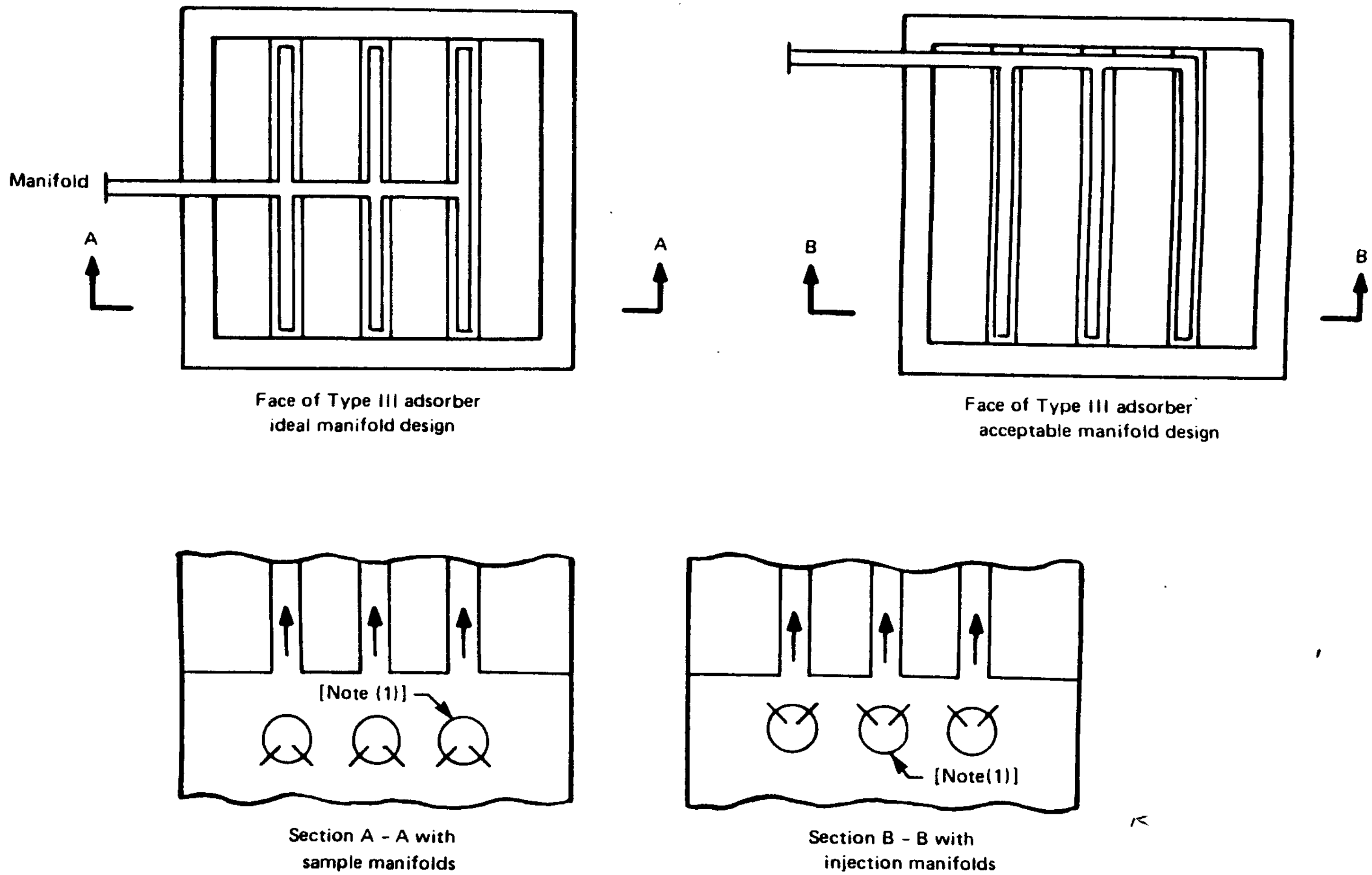


GENERAL NOTES.
(a) Injection of DOP/Halide is in inlet duct
(b) Downstream DOP/Halide sample point may be in outlet duct

NOTE:
(1) 1st stage Halide sample point can be used for 2nd stage upstream sample in lieu of single point sample

Plan E — Ducted Inlet/Outlet
HEPA-Carbon-Carbon-HEPA Configuration

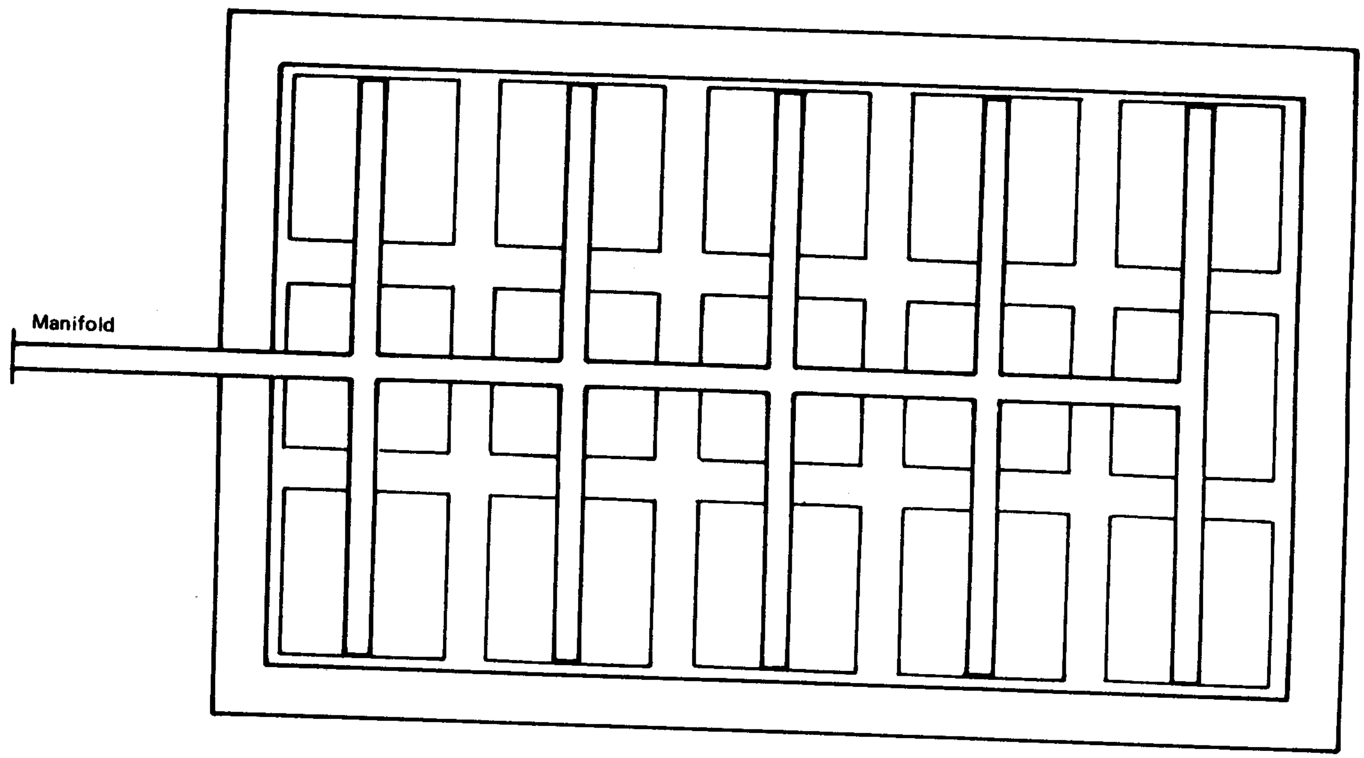
FIG. C-1 COMMON CONFIGURATIONS REQUIRING TEST MANIFOLDS (CONT'D)



NOTE:
(1) Manifold with 2 holes. See Fig. C-3 for alertnate when turbulence is required.

Sample and Injection Manifolds With Type III Adsorbers

FIG. C-2 [illegible] MANIFOLD DESIGN



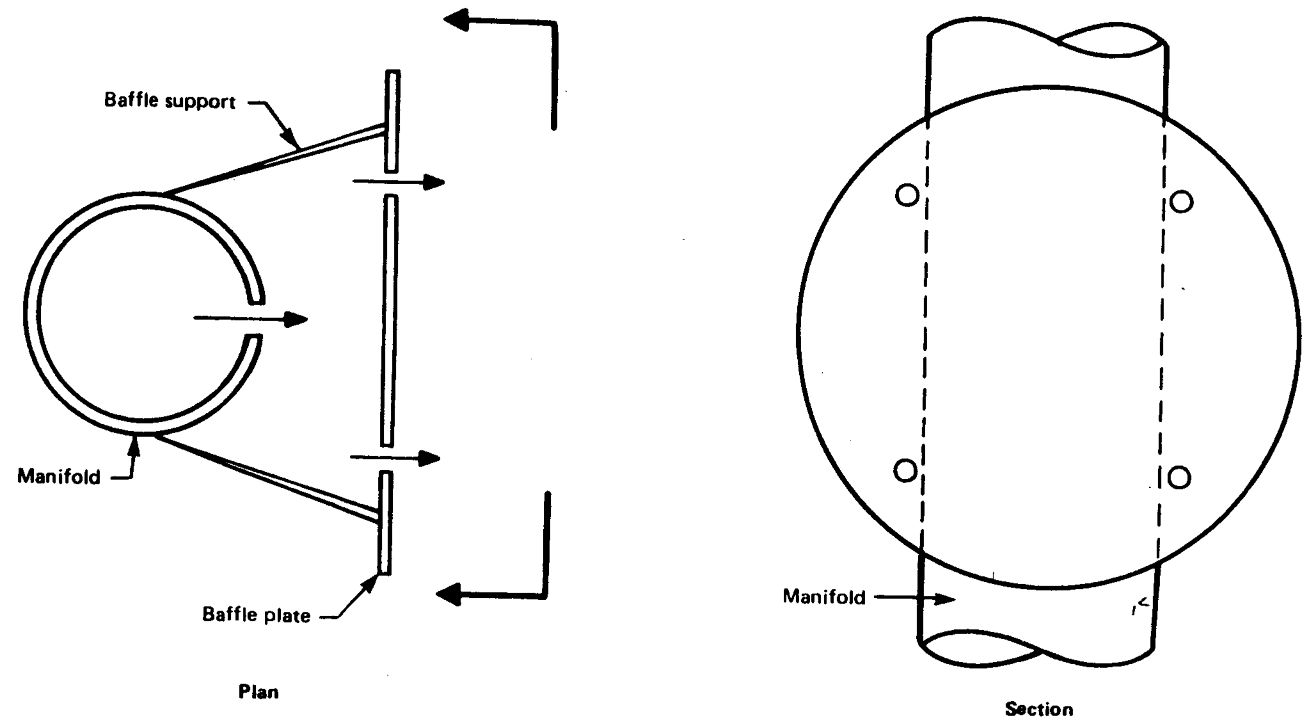
Face of HEPA filter bank

Ideal Manifold Design

GENERAL NOTE:
Many more sample points are required for Type II adsorbers and HEPA filters than for Type III adsorbers.

Sample and Injection Manifolds With Type II Adsorbers or Downstream HEPA Filters

FIG. C-2 GENERAL APPROACH TO MANIFOLD DESIGN (CONT'D)



Alternate Detail for Injection Sampling Manifold Baffle Design When Turbulence is Required

FIG. C-3 ALTERNATE DETAIL FOR INJECTION SAMPLING MANIFOLD BAFFLE DESIGN WHEN TURBULENCE IS REQUIRED

MANDATORY APPENDIX D
Performance Test for Qualification of Sampling Manifolds

(This Appendix is an integral part of ASME N509-1989, and is placed after the main text for convenience.)

D1 PURPOSE

The purpose of this test is to provide objective data that installed sampling manifolds provide a representative sample for subsequent component bank leak tests performed in the field per ASME N510-1989.

D2 LIMITS

This is a factory test for sampling manifolds. IT CANNOT BE PERFORMED IN THE FIELD.

D3 TEST REQUIREMENTS

D3.1 The housing, component banks, and sampling manifolds shall be complete and in their final ready-for-use configuration. Any later modifications shall invalidate this test.

D3.2 DOP aerosol shall be used to qualify all sampling manifolds including, halide sampling manifolds.

D3.3 DOP aerosol test equipment shall conform to the requirements of ASME N510 for DOP aerosol leak testing of HEPA filter banks.

D3.4 The test shall be conducted at the housing design flow rate ± 10%. If more than one flow rate is required for operation, a manifold performance test shall be performed at each flow rate. If the design has a variable flow rate, then the minimum and maximum (± 10%) shall both be used to perform the tests. Airflow distribution testing per para. 5.6.5.5 shall be performed as a prerequisite to manifold qualification tests.

D3.5 A temporary duct and fan shall be provided downstream of the housing. The duct shall be long enough and have provisions sufficient to guarantee mixing so that a representative single point sample may be taken. Baffles, vanes, or other means of providing good mixing are acceptable in the duct assembly. These shall be clearly shown on the [illegible] and documented sufficiently for independent review. The basis for 100% mixing shall be documented. When downstream of sampling a fan, mixing may be assumed acceptable.

In other configurations, the number [illegible]nple points shall be in accordance with Chapter [illegible] Industrial Ventilation. If necessary the number of [illegible]ing points, mixing, or duct length shall be in[illegible] so each sampled concentration is ± 5% of the [illegible]ated average.

D3.6 The temporary duct and fan assembl[illegible]ld be leak tight so no dilution air can enter or lea[illegible] test boundary. This shall be confirmed by a documented leak test in accordance with ASME N510.

D3.7 A visual inspection using applicable [illegible]tions of ASME N510 Visual Inspection checklist shall be performed after the test setup is completed, but before the test is performed. Nonconformances shall be resolved before the test is performed.

D3.8 Test engineers and technicians shall be qualified in accordance with ANSI/ASME NQA-1. A Level II Test Engineer shall prepare the test procedure and review the test results for acceptance.

D4 TEST METHOD

D4.1 The basis of the test is to compare the single-point aerosol concentration taken in the temporary test duct with that obtained from the sampling manifold under test.

D4.2 Test data shall be taken with all filter elements and adsorbent installed, and:

(*a*) without any aritificial leak paths;

(*b*) with one or more aritificial leak paths, as follows:

(*1*) the artificial leak paths shall be located, one at a time, to simulate leaks in the filter/adsorbent face, the frame-to-wall welds (including floor and ceiling), and gasket-to-frame seals (where applicable), and at structural welds on Type III adsorbers;

(*2*) the number and exact placement of the artificial leak paths depends on the size and configuration of the bank and housing, but shall be no less than 10 with at least four at frame-to-wall floor ceiling locations. Tests with multiple leak paths are permissible after the required 10 tests with single leak paths are performed.

D4.3 Concentration shall be measured in the temporary duct and then using the sampling manifold. For each test condition the single-point sample concentration shall be the average of the traverse readings in the temporary duct.

D4.4 If the sample manifold concentration does not correspond to the single point sample within ±5%, the sample manifold shall be modified to produce a sample within ±5% for all test conditions.

D4.4.1 One method to determine where the nonuniformity in concentration exists is to scan in front of the manifold while the challenge aerosol is flowing. This will provide data to assist the redesign/modification of the manifold.

D4.5 Upon successful completion of the test, any excess DOP shall be removed from the housing, manifold, and associated hardware to avoid false readings in the future.

D5 ACCEPTANCE CRITERIA

D5.1 Single-Point Sample

The traverse concentration measurements taken at the single-point sample location shall be within ±5% of the calculated average concentration.

D5.2 Sample Manifold

The sample manifold concentration shall be within ±5% of the single-point sample concentration for all aritificial leak paths.

D6 DOCUMENTATION

D6.1 A sketch of the factory test setup shall be provided. It shall provide sufficient dimensions and detail to allow analysis by the owner prior to start of testing.

D6.2 The details of the test instruments for airflow and DOP generation and detection shall be provided. They shall include, as a minimum, the manufacturer, model, serial number, and calibration date.

D6.3 Test procedure shall be submitted to the Owner for review prior to the start of testing. All quantitative data shall be presented in a manner that will allow independent analysis of the test.

D6.4 The location, date, and test en[illegible]rs technicians shall be listed with signatures.

D6.5 An ANSI/ASME NQA-1, Level II [illegible] engineer shall sign the test report to be submitted [illegible] the owner for review prior to shipping the air-cleaning units.

D7 ACCEPTANCE OF RESULTS

D7.1 The owner shall review the detailed test procedure, including drawings of the temporary duct and hardware, before the test is performed and shall provide comments to the testing organizations.

D7.2 The owner shall review the results of the test before the housings are shipped. It is recommended that such approval be before the test assembly is dismantled. The owner shall advise the manufacturer, in writing, of acceptance of sampling manifold qualification test results prior to the unit's being shipped.

ASME N509 Interpretations — No. 1

Replies to Technical Inquiries
June 1989 — November 1990

FOREWORD

This publication includes all of the written replies issued between the indicated dates by the Secretary, speaking for the ASME CONAGT Committee, Committee on Nuclear Air and Gas Treatment, to inquiries concerning interpretations of technical aspects of ASME N509, Nuclear Power Plant Air Cleaning Units and Components.

These replies are taken verbatim from the original letters except for a few typographical corrections and some minor editorial corrections made for the purpose of improved clarity. In a few instances, a review of the interpretations revealed a need for corrections of a technical nature: in these cases a corrected interpretation immediately follows the original reply.

These interpretations were prepared in accordance with the accredited ASME procedures. ASME procedures provide for reconsideration of these interpretations when or if additional information is available which the inquirer believes might affect the interpretation. Further, persons aggrieved by this interpretation may appeal to the cognizant ASME committee or subcommittee. ASME does not "approve," "certify," "rate," or "endorse" any item, construction, proprietary device, or activity

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Date of Issuance: December 20, 1990

ASME N509 Interpretations — No. 2

Replies to Technical Inquiries
November 1990 — June 1992

FOREWORD

This publication includes all of the written replies issued between the indicated dates by the Secretary, speaking for the ASME CONAGT Committee, Committee on Nuclear Air and Gas Treatment, to inquiries concerning interpretations of technical aspects of ASME N509, Nuclear Power Plant Air Cleaning Units and Components.

These replies are taken verbatim from the original letters except for a few typographical corrections and some minor editorial corrections made for the purpose of improved clarity. In a few instances, a review of the interpretations revealed a need for corrections of a technical nature: these cases a corrected interpretation immediately follows the original reply.

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Interpretation: 91-1

Subject: ASME N509-1989, Section 7.3, Welding

Date Issued: April 30, 1992

Question: Is ASME AG-1-1991, Section AA-6300 an acceptable alternative to N509, Section 7.3?

Reply: Yes.